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MINERAL RESOURCES.

No. 1.

NOTES ON CHROMIC IRON ORE:

Its Modes of Occurrence, Mining, Dressing, Uses, and Value;

WITH A

REGISTER OF NEW SOUTH WALES LOCALITIES.

BY

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REGISTER OF NEW SOUTH WALES LOCALITIES.

The chrome mining industry in New South Wales is of very recent date, though an abortive attempt was made to inaugurate it as early as 1882 in connection with deposits at Bowling Alley Point, Peel River. Trial parcels dispatched at that time, aggregating 100 tons, tested the market in Melbourne, Liverpool, and London. The highest realization, however—viz., 70s. per ton—was insufficient for profitable working under then existing conditions of land carriage, &c.

Attention was next directed to the chromite deposits of the Clarence River District; and, with a view of eliciting information as to the possibilities of the industry in that locality, Mr. Geological Surveyor (now Professor) David was instructed in 1891 to examine the outcrops. Extracts from his published report bearing on the mode of occurrence, quality, and probable extent of the ore bodies will be found under the head of "Gordonbrook" in the register of occurrences in these Notes. No practical attempt to test the market value of the ore, or the feasibility of profitable working, appears to have followed at that time.

In 1892, Mr. Wright, a chemist at Mittagong, interested himself in a group of chromite deposits on the east fall of Mooney Mooney Range, about 4 miles north-easterly from Coolac railway station. These eventually became the scene of the first practical mining operations, over 2,000 tons being dispatched from them during 1894 and 1895. The site, originally known as Wright's Mine, afterwards became the Vulcan Mine.

The opening of the Coolac Mine directed attention shortly afterwards to another group of deposits on the north and south falls of Mount Lightning, about 5 miles southerly along the same range, of which Mount Lightning is an isolated mass cut off by the intersecting channels of the Murrumbidgee River and Adjungbilly Creek, about 18 miles above the town of Gundagai (on the same river), the terminal railway station in that direction.

Several large ore-bodies occur on the flanks of the mountain, those on the north fall being designated Quilter's Mines, and those on the south Mount Mary Mine. Under this heading descriptions will be found in the Register.

Practical mining and export began in this district in 1893, which caused not only local prospecting activity, but also general search throughout the Colony wherever serpentine was known to exist. Numerous discoveries of chromite followed, but only in the Gundagai-Tumut District did they become a source of profitable mining enterprise. In other localities, distance of land carriage in some instances, and inferior quality in others, retarded or altogether deterred extended prospecting.

The successful operations achieved in the Gundagai district stimulated further effort in that of the Clarence River, a fresh attempt being made in 1895 to turn those of Gordonbrook to account. A shipment of 30 tons was dispatched to test the market, with what financial result is not known; evidently, however, it not was sufficienly encouraging for continued effort. Lengthy land carriage and moderate quality combined are believed to have been serious obstacles to success in this instance—obstacles, however, capable of being modified or obviated in the future by improved roads and methods of ore dressing and concentration.

During 1894, 1895, and 1896 the chrome mining industry continued to flourish, the exports being 3,034, 4,299, and 3,851 tons respectively, but latterly it has languished and the output depreciated in consequence. The export for 1897 amounted to 3,379 tons, but a considerably less amount was actually mined during the year. The present is, therefore, an opportune time to review the situation and discuss the causes of fluctuation. A glance at the principal sources of the world's annual production of chromite may also be advantageously taken, especially for purposes of comparison of its chief modes of occurrence. It will also be useful to note its uses and value, and the latest methods of dressing and concentration of the crude ore for market.

Sources of Supply.

The principal supplies of chromite are drawn from Turkey, Russia, Greece, California, Canada, New Caledonia, and New South Wales. Of these countries, Turkey and Russia are reported to be the largest producers.

The following particulars are extracted from volumes ii and v of "Mineral Industry"*:—"The chrome deposits of Turkey, in the Province of Brousa, in Asia Minor, have for many years afforded the largest supply for the world's markets; but recent reports are to the effect that the supply is showing signs of exhaustion especially as regards the richer grades.

The Turkish ores are noted for their richness and freedom from silica, which is an objectionable ingredient equally in furnace lining and in the manufacture of bichromate salts.

From Macedonia the export is increasing, owing chiefly to the increased facilities of transport to seaboard. The best grades assay 55 per cent. chromium sesquioxide. The exports are reported to amount to 10,000 to 12,000 tons per annum.

For comparison, and as an index to values, the following analyses of Turkish ores are taken from Vol. v, page 155, of the work already quoted:—

	(1)	(2)	(3)
Sesquioxide of chromium	55·04	51·70	56·80
Protoxide of iron	12·63	14·20	12·06
Alumina	11·84	14·10	14·00
Magnesia	16·19	14·30	15·00
Silica	2·00	3·50	1·45
Lime	1·46	1·70	0·70
Water	0·40	0·30	0·15
	99·56	99·80	100·16

The value of the above ores is stated to have been (at the then ruling market rates, 1893), £5 10s. per ton in Europe for 50 per cent. chromium sesquioxide, with 5s. per unit additional for each unit above 50 per cent.†

* The Mineral Industry, its Statistics, Technology, and Trade, 1893, ii, p. 155. *Ibid*, 1896, v, pp. 119–21.
† Mineral Industry, 1893, ii, p. 155.

The Russian chromite deposits occur in the Ural Mountains. Formerly the ore raised was exported, but the recent local establishment of bichromate manufactories absorbs almost the entire output, which amounts to about 2,000 tons annually.

The Grecian output is reported to be very irregular, ranging from 200 to 1,400 tons per annum.

Though previously mined in large quantities for a long period in Maryland and Pennsylvania, U.S., chromite is now practically only produced in California. The most important deposits occur in Sans Luis Obispo County, but the ore is reported to be too low grade and scattered to pay at present prices. The average grade of California ores, in fact, is low, ranging from 43 to 47 per cent. Under the head of concentration, further reference will be made to them.

The production for 1895 amounted to 1,740 tons; and for 1896, 786 tons.

The production of chromite in Canada is of very recent date, the recorded output prior to 1894 only amounting to 50 tons. The output for 1895 was 3,177 tons; and for 1896, 2,362 tons.* The deposits occur irregularly and in small pockets in the serpentine belts of Quebec. The ore is of comparatively low grade, and is principally used for furnace lining in Pennsylvania.

Large quantities of chromite are reported to be again coming forward from New Caledonia, where large and rich deposits occur on the seaboard. The following description is from "Mineral Industry" † :—"Chrome iron ore occurs in great abundance in New Caledonia, where it was first mined in 1875, the ore being a constant associate of the serpentine rock of which a great portion of the island is composed. The most important deposits are those of Mont d'Or, N'Go River, and Canoe Bay, which are near the sea, and are connected with the port of shipment by a short railway. The ore exported averages 50 per cent. Cr_2O_3. Alluvial ores are also met with at a great number of points in the south of the island, forming beds 30 inches in thickness. . . . . There are also in New Caledonia large deposits of iron ore, containing 50 per cent. of iron and 2 to 5 per cent. of chromium sesquioxide. These occur in large masses of red clay in the serpentine country rock, which have been formed from the decomposition of the rock itself. This ore is low in phosphorus."

A similar iron ore is reported to occur in large quantity in Tasmania.

The chrome mining industry in New Caledonia is most advantageously circumstanced as regards proximity to seaboard, purity, and low-priced (convict and native) labour; hence it will always be a formidable rival to Australian chrome mining, where the conditions are not so favourable.

Detailed descriptions of the known New South Wales deposits will be found in the Register forming part of this paper.

From New Zealand, chromite was exported for a few years prior to 1866, but ceased in that year. At Dun Mountain, in the Nelson District, bands of the mineral 10 feet and 15 feet thick are reported. The Government Geologist, Mr. Alex. McKay,* reports‡ :—"Chrome ore occurs in New Zealand, chiefly in association with the magnesian rocks of the Dun Mountain mineral belt, in the Nelson provincial district. Associated with rocks of the same age and character, it also occurs in the mountainous district of North-west Otago and the southern parts of Westland.

"The chief developments of ore (in the Nelson District, J.E.C.) are found between the Upper Maitai Valley and the Lea River, a distance along the mineral belt of 12 miles. The ore occurs in elliptical masses, usually at a

* The Statistical Year Book of Canada, 1896, p. 102.
† The Mineral Industry: its Statistics, Technology, and Trade, 1893, ii, p. 156.
‡ The New Zealand Record, 1897, i, No. 5, p. 229.

given distance from the north-west margin of the mineral belt. Some of these deposits are of considerable size, and the total of the ore exported from Nelson (5,666 tons, J.E.C.) was mainly from one outcrop supplemented by a lesser quantity from Little Ben Nevis."

Large chromite deposits have lately been discovered in Newfoundland, and are now being opened up. There are, in addition to the above, other less important sources of supply, which need not be mentioned here.

Modes of occurrence of Chromite.

Under this heading, attention will only be paid to occurrence in commercial quantity. The mode of occurrence of commercial chromic iron ore in all producing countries is characterised by uniformity of physical conditions. As a general rule, it forms "bunches" or "pockets" in serpentine, usually of comparatively small size; and occasionally in alluvial deposits resulting from weathering and denudation of the enclosing rock. A few notable exceptions to the general rule regarding size of chromite bunches occur in Turkey, and in Maryland, and Pennsylvania, in the United States; and, it is believed, also in New Caledonia. A few large deposits in Turkey, have for nearly fifty years, continued to afford the principal part of the World's supply. According to Dr. D. T. Day*, Reed's Mine, Harford County, Maryland, produced over 100,000 tons of ore before exhaustion. Another very notable exception was the Great Wood Pit, Lancaster, Pennsylvania, which, according to the same authority, was worked to a depth of 700 feet, and for forty or fifty years afforded the greatest part of the world's supply.

The following description of the occurrence of chromite covers the general run of chromite deposits, and is especially applicable to those of New South Wales so far discovered:—"The chrome mining industry in California has never been put upon a permanent basis, however, owing chiefly to the irregularity in the occurrence of the mineral and the peculiar local conditions. As elsewhere in the world, the chrome ore there is found in serpentine, whence it is easily mined, but it usually occurs in small pockets, which are soon exhausted; indeed, as a rule, the deposits are too small to warrant the outlay of much capital for their exploitation, and mining is consequently comparatively expensive."†

In Turkey, the oreforms irregular pockets and masses in serpentine, which are worked in open cut.

The Russian deposits are classified by Gustave Rose under three heads:—(1) Those which occur in large granular masses in serpentine; (2) those where the mineral is finely disseminated through the rock; and (3) in alluvial deposits.‡

In "A Treatise on Ore Deposits" by J. A. Phillips and Henry Louis, 1896, p. 182, the following extract is quoted from Vogt:—"Deposits of chromite all the world over are basic magmatic segregations from peridotite, occurring as lenticular masses of varying dimensions in peridotite or in serpentine, resulting from the alteration of the rock"; in other words, the chromite segregated into masses whilst the original matrix—peridotite—was in the condition of a pasty or viscid magma.

Professor Garrison describes different forms of chromite deposits thus§:—"They have no orderly mode of occurrence or of extension of figure. They are neither veins nor beds nor fissures, but are ore pockets, each of which must be considered as a complete unit, having no relation whatever to any

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* The Mineral Industry, 1898, ii. † *Ibid*, pp. 151-2. ‡ *Ibid*, 1893, ii, p. 158.
§ Ann. Rept. U.S. Geol. Survey, 1895-96, xvii, pt. iii, pp. 261-272.

other pocket in the region in which it may exist. So far as concerns chrome mines, it would be futile to argue the position of an unknown pocket from the basis of any known ore."

From the above extracts and quotations it will be seen that the discouraging features of New South Wales chrome mining are not peculiar to this country; moreover, they serve to emphasise the views expressed in my second report on the Gandagai-Tumut chrome field†:—"Chrome mining in the districts in question has now been advanced to a stage which enables a fairly clear opinion to be formed of the nature and mode of occurrence of the deposits; and the experience of the past year teaches that they in no way differ from those of other countries which have been described as "pockety" and "bunchy," "irregular" and "uncertain." Therefore it seems imperative, if the chrome industry is to be advanced and maintained as a profitable commercial undertaking, that systematic prospecting must be kept well ahead, not only of actual winning, but also of actual discovery, so that new finds may be made available as the old give out, and thus prevent frequent cessation of work.

With resolute grasping of the fact of comparatively small but numerous and widespread deposits, coupled with systematic prospecting and proving, careful blending of ores and uniformity of grade, and by saving and concentration of smalls where practicable, there can be no doubt that the chrome industry of the Colony will be maintained on a vigorous and profitable scale.

In prospecting, it will be wise not to confine the search to surface outcrops of deposits, but to extend it to alluvial deposits; for, as already mentioned, commercial accumulations of chromite detritus are worked both in Russia and New Caledonia. In passing along the serpentine belt between Tumut and Mount Lightning, chromite rubble was frequently observed on grassless patches and in small rivulets on the slopes of the ridges. Advantage should be taken of these indications to trace by loaming—washing portions of soil—the source of the liberated particles; for though they may in some instances be derived from serpentine containing the mineral sparingly distributed through the mass (as chromite is always present in small proportion in serpentine), yet there is always reasonable prospect of it being shed from segregated masses, which at the present time are obscured by soil.

An instance of natural concentration of disseminated particles liberated by decomposition is furnished on a very small scale at Port Macquarie, where the now coherent grains form small patches assaying 48 per cent. of chromium sesquioxide.

Dressing and Concentration of Chromite.

The necessity of concentration is a question which is forcing itself on the attention of those interested in chrome mining. In California, where much of the ore at present accessible is of low grade, concentration has already been adopted; for, as pointed out in the valuable work already freely quoted ("Mineral Industry"), "the future of the chrome industry in California seems to depend upon more careful dressing of the ore, either by hand or mechanically." There can be no question that, apart from utilising deposits of low-grade ores in this way, the great market desideratum, viz., uniformity of grade, would be secured by dressing and concentration.

Where the ore is rich the usual practice of cobbing and hand-picking is sufficient to secure a high grade, but generally the richest ores are the most friable; hence considerable loss is entailed as smalls during the present

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† Ann. Rept. Dept. Mines and Agric., N.S. Wales, for 1896, p. 123.

process of mining and hand-dressing. The rich fragments which thus become mixed with the waste could be recovered by concentrating machinery. Hard, compact ore of low grade, in which the impurities are finely and intimately mixed, may not prove as amenable to concentrating treatment as comparatively lower-grade ores roughly mixed with serpentinous impurities. The latter, in cases where the serpentine has decomposed into magnesium clays, would probably afford special facilities for concentration. The hard ore in question might be utilised in two ways: after coarsely crushing and washing it might be mixed in carefully ascertained proportion with the rich concentrates to ensure an uniform grade of good quality; or it might be made available for furnace lining if the market rate afforded a margin of profit.

Touching the method of concentration, the following description of a plant running in California is valuable as a guide*:—"One of the chrome dressing works now in active operation in California is equipped as follows:—Rock-breaker, 6-ft. Huntingdon mill, and four Woodbury vanners with corrugated belts, together with settling tanks, drying floors, and the usual driving machinery, &c. The plant, which is capable of turning out from 20 to 25 tons of dry concentrates per twenty-four hours, cost about 12,000 dollars (£2,400). The process is carried out as follows:—The ore is crushed by the breaker and the Huntingdon mill so as to pass a 40-mesh sieve. The pulp is separated on the Woodbury vanners. The concentrates are collected in settling tanks, whence they are removed to the drying floors, and finally packed for shipment in strong jute bags."

The fuel used is wood. The crude ore does not cost more than 7 dollars (28s.) per ton for best grades, delivered at the mill.

The result of a month's run of the above mill is stated to have been 700 tons (2,000 lb. per ton) of 50 per cent. concentrates, which at the then market rates (1893) yielded a profit of 3 dollars (12s. 6d.) per ton, and 1 dollar (4s. 2d.) per ton for each 1 per cent. above 50 per cent. produced.

The following analyses give the results of the concentration of Californian crude ore†:—

	Crude Ore.	Concentrates.
Sesquioxide of chromium	43·70	52·86
Protoxide of iron	14·80	15·45
Alumina	15·96	11·59
Magnesia	16·49	16·26
Silica	7·96	3·00
Lime	·66	·76
Water	·49	·10
	100·06	100·02

Owing to the varying percentages of sesquioxide of chromium contained in chromite, it is recommended that preliminary panning or hand-jigging tests, with careful analysis of results, should first be made to ascertain the suitability of the various ores for treatment on a large scale of concentration.

With regard to concentration of New South Wales low-grade chromite and smalls resulting from mining and hand-dressing, both the Gundagai-Tumut and Clarence River deposits appear to offer fair fields for practical tests. At Mount Lightning, Adjungbilly, and Brungle Creeks, a plentiful water supply is available for such operations; but looking at the question in a larger light than individual interests, and having regard to the scattered occurrence of the deposits and the comparatively limited amounts of material

* Mineral Industry, 1893, ii, pp. 153–4. † Mineral Industry, 1893, ii, p. 153.

available at any one mine or group of mines, there can be no question that the establishment of a central dressing and concentrating plant on the Murrumbidgee River—(say) at Gundagai, the present railway terminus in the district—would best serve the interests of the whole field. Low-grade ores, seconds, and smalls, could be disposed of to such an establishment on bulk assay values.

Uses of Chromic Iron Ore.

Before discussing the uses of chromite it will be useful to briefly note its physical characteristics and chemical composition. The metal chromium (of which chromite is an oxide), according to R. A. Hadfield,* has an atomic weight of 52·40, and a specific gravity of 6·8–7·3, with a high melting point not yet determined.

Chromium is used in the metallic state only in making chrome steel, and even in this instance it is used as ferro-chromium. Quite recently M. Henri Moissan† has demonstrated the possibility of manufacturing pure chromium and tungsten in commercial quantities. His latest method is to take a carbon pipe filled with the metallic oxide mixed with carbon, inclining it, and subjecting it to the electric current; the metal contaminated with carbon readily flows off as a result of the reaction. Two carbides of chromium have been identified. The carbides are purified by remelting with lime.

Chrome steel is used chiefly in the manufacture of armour plates and armour-piercing projectiles, for shoes and dies in stamper batteries, and for burglar-proof safes and edge tools. Professor Garrison states that the "extreme hardness of the chromium steel face is dependent upon the content of carbon, whose action is intensified by the presence of the chromium, and is only developed after the steel has passed through a system of hardening. This tempering consists essentially in heating the plate to a red heat, and quenching it with sprays of ice water."‡ Sir Frederick A. Abel, in his presidential address before the British Association for the Advancement of Science, Leeds, 1890, stated that "chrome steel has for some time been a formidable rival of the very highest qualities of carbon steel produced for cutting tools, and of the valuable tungsten steel. The great hardness, high tenacity, and exceeding closeness of structure possessed by suitably tempered steel containing not more than from 0·8 to 1 per cent. of carbon, renders this material invaluable for war purposes. Cast projectiles, when suitably tempered, have penetrated compound steel and iron plates over 9 inches in thickness, such as are used upon armoured ships of war, without even sustaining an important change of form."

The presence of a small percentage of chromium in gun-metal is also likely to prove beneficial. Chromium is used in the production of first quality steel rails for railway purposes. Steel with 1 to 1·5 per cent. of carbon and from 2·5 to 4 per cent. of chromium is stated to be so hard that it cannot be worked with the ordinary hardened tools; consequently it has been called into requisition for the construction of burglar-proof safes. For this purpose it is welded and rolled with iron plates.

Chromite is the most common ore of chromium. Its composition, according to Dana, is—chromium sesquioxide, 68·0; iron protoxide, 32·0=100. Specific gravity, 4·32 to 4·57; hardness, 5·5; colour between iron-black and brownish-black, generally exhibiting emerald-green encrustations on smooth semi-conchoidal faces; lustre, sub-metallic to metallic, sometimes feebly magnetic.

Tests.—Before blowpipe in oxidising flame, infusible; in reducing flame, slightly rounded on the edges, and becomes magnetic.

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* Journal Iron and Steel Institute, 1892, ii, p. 53. † Engineering and Mining Journal, Nov. 6th, 1897, p. 550.
‡ Ann. Rept. U.S. Geol. Survey, 1894-95, xvi, pt. iii, pp. 610-14.

With borax and salt of phosphorus, gives beads which while hot show only reaction for iron, but on cooling become chrome-green. Not acted on by acids, but decomposed by fusion with potassium or sodium bisulphate.

Chromite is reported as not uncommon in meteoric iron.

Other ores of chromium occur, the chief of which is crocoisite—chromate of lead—in which the metal was first discovered.

Serpentine, in which the chrome deposits occur, owes its colour to chromium salts. The beautiful colour of the emerald and of ouvarovite (chrome-garnet) is due to the presence of chromium, and probably also that of the ruby and sapphire; for it has been demonstrated that if the formation of crystallised alumina is accomplished in the presence of chromium compounds, crystals having the colours of ruby and sapphire, as well as their composition, may be produced.*

The other varieties of chromium ores are of mineralogical interest only, and call for no special mention in this paper, which is concerned with the economic ore alone.

Chromite, or chromic iron ore, is used in the arts for the manufacture of potassium and sodium bichromates, for the preparation of basic furnace hearths, and for reduction to ferro-chromium for the production of chrome steel. By far the most part of the mineral produced is employed for the first purpose, for which only that of high grade can be economically used; while for furnace hearths, and for manufacture of ferro-chromium, ore of lower grade suffices. ("Mineral Industry," vol. ii, 1893, p. 158.)

Chromite is coming largely into use as a refractory lining for basic furnaces. The latest particulars available of its use in this direction are given in the last volume of "Mineral Industry,"† from which the following extracts are taken:—"At present the mineral is employed in reverberatory copper-smelting furnaces, and in open hearth steel furnaces, in both with very satisfactory results. Concerning the former, Herbert Lang writes‡: 'The Selby Smelting and Lead Company has used it quite extensively in the matting reverberatories at Vallejo Junction, California. The hearth is composed of large fragments of chrome ore, with the interstices well filled with smaller pieces, and the material is built up around the sides to the slag line. The protection is such that fettling is almost done away with; in fact, they have not to fettle but once a week or so. The chrome ore is acted on but slightly, if at all.' Alfred von der Rupp, Superintendent of the Works, states§ 'that the life of the furnace is more than doubled by the use of chromite.'"

In the "Mineral Industry," 1893, vol. ii, it is stated that chromite has been used instead of magnesite and dolomite in basic furnace hearths, the method of preparation of which is given as follows:—"In preparing basic furnaces with chromite linings, all parts of the walls with which the metal bath and slags come in contact are laid with pieces of chromite, cemented with a mortar consisting of two parts (by volume) of finely ground chromite, and one part of lime, burned as free from silica as possible. The hearth is made of stamped chromite ore, mixed with same kind of mortar. The ore should be as rich as possible in chromic acid, containing from 40 to 45 per cent."

In Vol. ii, 1895, p. 506, of the "Journal of the Iron and Steel Institute," reference is made to an article in "L'Echo des Mines," vol. xxi, page 548, as follows:—"According to P. Speier, chrome ore linings for reverberatory

* Precious Stones and their Artificial Production; by Prof. J. W. Judd, C.B., LL.D., F.R.S.—Roy. Coll. of Science Magazine, No. 74, vol. viii, pt. 9, p. 268.
† The Mineral Industry, &c., 1896, vol. v, pp. 120-3.
‡ Engineering and Mining Journal, January 23rd, 1897, p. 89.
§ Mining and Scientific Press, Sept. 26th, 1896, p. 257.

furnaces have been successfully adopted in French, German, and Russian steel works. The bottom and walls of the furnace are lined with chrome ore in large blocks, united by a cement formed by two parts of chrome ore finely ground, and one part of lime, as free from silica as possible. . . . The iron chromate is decomposed only under the influence exerted by the reagents and oxidising alkaline substances. Heat alone is insufficient to decompose chromate of iron, which may float in a bath of molten steel covered with basic slag without dissolving. One of the principal conditions of success in the employment of the chrome ore lining consists in carefully picking the pieces of ore used, which should be of uniform composition; and the best composition of ore used for lining reverberatory furnaces is found to be from 36 to 40 per cent. of chromic oxide, 18 to 22 per cent. of clay, 9 to 10 per cent. of magnesia, and at most 5 per cent. of silica."

Messrs. G. R. Blackwell, Sons, & Co., of Liverpool, England, are quoted for the statement that chrome ore had been used by steel manufacturers in Lancashire and Yorkshire for about fifteen years. They also remark that it is not necessary to make the chrome ore into bricks, a better method being to crush it to pea size, mix with tar, and line the furnace as if with mortar. The tar burns away, leaving a solid lining of chrome ore, which has been found to give satisfactory results.

The consumption of chrome ore in open hearth basic furnaces in the United States amounts to about 1,800 to 2,000 tons annually, according to the publication quoted ("Mineral Industry"), the Pittsburg supply being for the most part from the Province of Quebec. The requirement is for an ore of not less than 45 per cent. chromium sesquioxide, but the shipments are reported to rarely average so high. The ore is used in lump form for patching the sides of the basic lined furnaces, and is found far more convenient and durable than a slurry of dolomite.

According to the same authority, very hard and lasting chrome bricks are manufactured at Pittsburg for use as a neutral parting between the basic hearth and silica roof.

In connection with the rapidly increasing use of chromite as a refractory furnace lining, the comparatively low grade of material suitable for this purpose should have an important bearing in the near future on the local chrome mining industry, for increasing demand the natural correlative of increasing use is almost certain to give a remunerative value to ore at present below the minimum market grade, deposits of which are already known to exist in the local chrome fields.

Buyers still stipulate for high grades of 50 per cent., or more; probably 47 per cent. is about the lowest local grade for which a price would be quoted at the present time. It will, however, be noted in the quotations and extracts embodied in this paper that the stipulated grade of chrome ore for furnace lining at Pittsburg, U.S., is 45 per cent., and even this comparatively low grade percentage is reported to be rarely reached. The average percentage of chromic-acid in furnace lining may be taken as about 40 to 45. In chrome steel manufacture, or more correctly in the preparation of its preliminary stage of ferro-chromium, low grade ores of the above character are reported to be suitable.

Whilst fair supplies of rich ore are procurable from Asia Minor, Greece, and New Caledonia at about 75s. per ton (f.o.b.) for 50 per cent. ore, and 2s. per unit in excess, as has recently been quoted in a letter from Cologne to the Department of Mines and Agriculture in this Colony*, much lower than fairly proportional values will rule for low grades; still there is reasonable

* From F. E. Clotten, 136, High-street, Cologne, Germany.

hope that increased consumption in the latest sphere of usefulness will correspondingly increase the value of lower grades, and thus render remunerative local deposits of this character known to exist within easy reach of railway carriage.

Railway concessions for transport of crude ores to seaboard have been steadily increasing until the rate per ton per mile has reached a nominal figure. Shipping freights can also be arranged for them at exceptionally low rates owing to the effective stiffening they afford to wool ships and other carriers of bulky cargo.

Attention is also directed to another bearing which the successful use of chromite as a refractory furnace lining may have on local industry, viz., the possibility of local consumption in connection with copper and matting furnaces, to say nothing of the iron smelting furnaces of the—it is hoped—near future. Doubling the life of a furnace and reducing fettling to a minimum—as proved in other countries—by the use of chromite lining, should induce practical tests in this Colony.

The chief use of chromite at the present time is in the preparation of chemical salts for use in the arts, in painting, calico printing, dyeing, and tanning. Chrome pigments embrace various shades of red, yellow, green, buff, and black. Green oxide of chromium is used extensively as an enamel colour for porcelain.

A new use for chromite is reported from France, where a compound known as *Silichromite* is manufactured. According to "Mineral Industry" (vol. v, 1896, p. 123) "it is an extremely hard, crystallized substance, but easy to pulverize, and is used for moulding and polishing purposes. It is prepared by treating chrome ore, sand, and coal, in an electric furnace, wherein a molten mass, in which chromium silicate predominates, is obtained."

Register of Chromite Occurrences in New South Wales, with Notes and Descriptions.

*Adjungbilly Creek, Parish Darbalara, County Buccleugh.**—On the south side of Mount Lightning, close to the Adjungbilly Creek, Messrs. Carroll and Gillespie were working on tribute an area on Mr. Quilter's property, known as the Mount Mary Mine. At the time of my inspection in 1895, about 400 tons had been despatched, averaging, according to the tributors' statement, from 43 to 49 per cent.

The main deposit was being worked by means of an open cut about 50 feet long, and 20 to 30 feet deep. The ore exposed under foot was solid, and about 7 feet in thickness, whilst a wedge of ore in the upper workings was left standing about 12 feet high and 10 feet thick.

Several smaller bunches were exposed by shallow cuts and trenches high up the slope of the mount.

The most important of the new finds was situated near the top of the mount, where a solid bunch about 10 feet by 4 feet outcropped above the soil.

On the south side of Adjungbilly Creek, on the continuation of the serpentine ridge, Welsh's mine is situated. The only known deposit in this mine was exhausted for a yield of about 220 tons.

Angular Creek, County Murchison.—Chrome has been reported from this locality, but no particulars are known.

Attunga and Manilla—Between these localities a serpentine belt extends in N.N.W. direction. Several chrome deposits have been reported in it by Mr. C. S. M'Glew; but, so far as his prospecting extended, none were of sufficient size to induce mining for export.

* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126.

Armidale.—Samples submitted for assay in 1884 and 1886 from the Armidale district yielded 38·5 and 43 per cent. respectively.

Barraba.—Chromite from this district, assayed in 1888 and 1895, yielded 40 to 44 per cent.

Bendemeer.—Chromite, assaying 38·5, submitted in 1884.

Berthong Run, near Wallendbeen.—Mr. Geological Surveyor Jaquet has described the Berthong chrome deposits as follows:—"Chromite has recently been discovered upon Berthong Run, but nothing has yet been done in the way of proving the extent of the deposits. In the bed of Berthong Creek a shallow trench of 5 feet long and 2 feet broad has been cut through a mass of this mineral. Chrome ore has also been found in a shallow trench put down upon the banks of a tributary of Berthong Creek. In the vicinity of the discoveries, and over a large portion of the serpentine zone, the bed-rock is hidden by a shallow alluvial deposit, and it will be necessary for prospectors to find the ore bodies below."*

Samples forwarded from the above-described deposits yielded from 39·5 to 54·04 per cent.

Bingara.—Chromic iron deposits have been noted at Spring Creek, about 3 miles south-easterly from Bingara, by Geological Surveyor David, who reported that the serpentine in which they occur "forms an eruptive dyke from 3 to 5 chains wide, striking either north-westerly or northerly. Segregated masses of chrome iron are observable at intervals in the serpentine,"† and one bunch is stated to measure about 7 feet by 6 feet. Two assays are recorded from the Bingara district, viz., 40·87 and 41·21, the localities being 12 and 14 miles south of Bingara.

Bowling Alley Point, near Nundle, Peel River.—As already mentioned the deposits of this locality were the first opened in the Colony—100 tons being mined in 1882.

The late Government Geologist, Mr. C. S. Wilkinson, F.G.S., &c., in one of his reports states that "on a high range about 1 mile north-east from Bowling Alley Point occurs a lode of almost pure chromite of variable thickness. In one place, at the junction of diorite and serpentine, it crops out on the surface 12 feet wide."‡

Professor Liversidge states that "the outcrop from which this was taken—(samples of chrome under description J.E.C.)—is about 700 feet above Bowling Alley Point, and the apparent thickness of the vein is in one part some 40 odd feet; one huge block of the mineral lying loose on the surface measures 12 feet long by 6 feet high, and 5 feet wide." A specimen from this locality is reported by the same author to have contained 64·72 per cent. chromium sesquioxide, and 21·11 per cent. iron protoxide.‖ Other assays in 1892 are recorded varying from 37·42 to 43·50 per cent.

Brawlin, from foot of Cowong Range, 7 miles south-east.—A sample forwarded for assay, bearing the above locality, yielded 31·13 per cent.

Brungle Creek, Parish Wyangle County Buccleugh.—¶The Emu and Mount Miller Mines occur on either side of this creek, near the crossing of the Tumut-Tomorrowmah Road. The serpentine is here deeply intersected by the creek and its tributaries. The Emu Mine at the time of inspection consisted of two bunches of chromite, one rather superficial, the other of better promise as regards size, but not as regards quality. Abundant water supply in close proximity to both the mines mentioned should afford the best means of ensuring a high grade product for export.

Mount Miller Mine is situated high upon the range on the opposite side of the creek. The deposits here are very small at surface. A sample from the outcrop yielded 48·13 per cent.

Assays from this locality are recorded from 32·16 to 52·54 per cent.

Clarence District.—See Gordonbrook.

Coolac.—See Wrights and Vulcan Mine, Mooney Mooney.

Cootamundra.—Assays are recorded of samples purporting to come from this locality—but which may be either Berthong or Coolac—from 45·75 to 57·82 per cent.

Copmanhurst.—Probably identical with Gordonbrook. Assays recorded from 40·71 to 45·45 per cent.

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* Ann. Rept. Dept. Mines and Agric. for 1895, pp. 179 and 180.
† Ann. Rept. Dept. Mines and Agric. for 1891, p. 235.
‡ Ann. Rept. Dept. Mines for 1885, p. 135. § Liversidge, Minerals of New South Wales, 1888, p. 106.
‖ Ibid. ¶ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 127.

Darbalara Parish, County Buccleugh.—See Quilters's Mines.

Emu Mine.—See Brungle Creek.

Eurongilly.—On Mr. Keogh's private land a small bunch of low grade chromite was noted, which had been broken from a loose block found in the soil which here is deep. The country consists of talcose slate. Assays are recorded from 40·9 to 41·38 per cent.

Gordonbrook, Clarence River.—Mr. Geological Surveyor David reported on the occurrence of chromite in this locality in 1891. They occur in the parish of Pucka, about 30 miles north-west from Grafton, at Oaky and Fine Flour Creeks.

"The deposits of chomite in this neighbourhood form two principal groups. . . They both occur in serpentine at a short distance from the edge of the Clarence Series. . . Besides these two formations a third is developed, which may be described as a fine-grained, greenish-black rock, slightly crystalline, and, probably, a highly altered rock, which might be termed epidiorite. . . . This rock appears to have been intruded by the serpentine, and the deposits of chromite marked A on the plans herewith occur chiefly along the junction line of this rock with the serpentine."*

In connection with the first group (A) in Portion 7, Parish Pucka, Mr. David measured the two larger bunches as 12 feet x 12 feet and 24 feet x 18 feet. In the latter the chromite was a good deal mixed with serpentine, and would require dressing to render it marketable.

Deposit B is reported as forming a bluff on the left bank of Oakey Creek, about 2 miles north-westerly from the first group. The second group consists of two bunches—the main one about 90 feet x 36 feet at its maximum width. The quality is reported as superior to that of A group.

At the time of inspection the above deposits were not proved beyond a few feet except in the main deposit of the second group (B), of which a natural section is available down to 20 feet in the creek channel.

Mr. David regarded the deposits as lens-shaped bodies, the vertical extension of which, probably, equals the horizontal. Calculating on the basis of these dimensions, he estimated that the known Gordonbrook deposits would yield approximately about 20,000 tons of chrome ore to a depth of 90 feet from surface.

Samples selected at the time of inspection yielded from 40·25 to 55·27 per cent. Others by Mr. W. A. Dixon, F.C.S., F.I.C., were quoted in the report from 39·7 to 48·61 per cent. Earlier assays (in 1886) are from 28·44 to 47·70.

Two attempts to open these deposits have been made in 1891 and 1895, but so far unsuccessfully. Perhaps cost of carriage is one of the chief reasons for non-success. From the mines to Copmanhurst, the nearest point of available water carriage on the Clarence River, a distance of about 24 miles, has to be negotiated with teams, part of which is over a rough road.

Gundagai District.—See Mooney Mooney, Vulcan, Quilter's Adjungbilly, and Kangaroo Mine.

Gwydir River.—Chromite is reported from the Gwydir River and its tributaries (see Bingara).

Gulgong (?).—A sample of rich chromite is reported from this locality, but no analysis or particulars are given.†

Grenfell.—From near Grenfell a sample yielding 43·22 per cent. is recorded.

Harden, County of.—See Mooney Mooney.

Houlahan, Parish of, County Clarendon.—Chromite from this locality yielded 40·71 per cent.

Ironbarks and Barraba.—Chromite from the serpentine of this district has been assayed for a yield of 46·45 per cent.

Ironbarks, between Ironbarks and Mudgee.—Chromite has been reported from between the places mentioned, but there are no particulars on record.

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* Ann. Rept. Dept. Mines and Agric. for 1891, p. 218.
† Ann. Rept. Dept. Mines for 1877, p. 211.

*Kangaroo Mountain, Kangaroo Mine,** *Parish Wagara, County Buccleugh.*—The Kangaroo Mine is situated in portion 128. It was opened in 1894 by Mr. M. Constable, under agreement with owner of the land, Mr. Robert Owen.

This deposit constitutes one of the most important of the chrome-field, both as regards extent and quality. At the time of inspection in February, 1895, the output was averaging about 100 tons per week, about 1,200 tons having been dispatched to that date.

Down to 30 feet the main open workings averaged about 75 feet x 25 feet x 30 feet. At this point the dangerous open work system of mining was abandoned in favour of a safer method of shafts and levels.

For about 200 feet the ore body was exposed by open cuts. At surface the solid chromite was narrow, but opened to about 18 feet in the widest part. In the open workings, at 30 feet level, the chromite exposed measured about 54 feet by a width of 4 feet.

The quality of the ore proved consistently good, the lowest average in account sales of 1,230 tons dispatched to the date mentioned was 53 per cent., and the highest 57 per cent. of chromium sesquioxide.

In addition to the Kangaroo Mine, about twelve other smaller deposits were discovered which yielded about 75 tons of marketable ore. Other pockets were known at the same time, but had not been opened.

Keefe's Mine,† *between Brungle and Bumbolee Creeks, County Buccleugh.*—At the time of inspection (February, 1895), little work had been done at this site, which is on private property. A small chromite bunch or pocket, about 6 feet long by 2 ft. 6 in. wide, had been opened for a few feet only. Most of the ore was mixed with country, and required dressing. Other deposits were reported on this property, and latterly more attention has been given them. Distance of team carriage, however, is reported to have prevented profitable mining being maintained at the present time.

King, County of, near Yass.—Chromite has been noted in this county, but no particulars are available.

Manning River, Upper.—A sample purporting to come from this locality has been assayed in the Departmental Laboratory for a yield of 46·19 per cent.

M'Inerny's Mine,‡ *near Bumbolee Creek,* 8 *miles from Tumut, situated near the south-west corner of Portion* 351, *Parish Mundongo, County Buccleugh.*—This site was also inspected in February, 1895. A few small bunches were then being prospected, but the quality of the ore was inferior. This mine was the furthest southerly in the serpentine belt at the date mentioned, the distance from the Gundagai railway station being about 30 miles.

Molong, 15 *miles west.*—A sample of chromite bearing this inscription was assayed for 24·08 per cent.

Moonbi, 12 *and* 15 *miles from.*—Numerous samples have been forwarded from this District. Assays are recorded from 39·21 to 43·30 per cent.

Mooney Mooney.—See Wright's and Vulcan Mine.

Mount Lightning.—See Quilter's and Mount Mary Mines, and Adjungbilly.

Mount Mary Mine.—See Adjungbilly.

Mount Miller Mine.—See Brungle Creek.

Murrumburrah.—Chromite reported as coming from this district yielded 44·40 per cent.

Nundle.—See Bowling Alley Point.

Oaky Creek—See Gordonbrook.

Paling Yard and Dry Diggings, (between).—Chromite sent for assay from this locality yielded 40·67 per cent.

Port Macquarie.—From the serpentine of Port Macquarie samples of coherent chrome iron sand have been received recently, which yielded 48·24 per cent. chromium sesquioxides and 1·29 per cent. of cobalt protoxide. No solid chromite pockets have yet been discovered in the neighbourhood, and the mode of occurrences of the compact sand points to the natural concentration of small disseminated particles of chromite liberated by weathering and decomposition of the serpentine. Magnetic iron oxide occurs at Port Macquarie under similar conditions.

Pucka.—See Gordon-brook.

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* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126. † *Ibid*, p. 127.
‡ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 127.

*Quilter's Mines**.—Of the six deposits of chromite described in my first report*, as occurring on Mr. John Quilter's property at Mount Lightning, three had been opened by the date of my second visit in February, 1895, and 1,100 tons of ore despatched mainly from two of the deposits. Both the latter presented very small outcrops. The open cut system had been adopted in winning the ore, but at 20 feet it had to be abandoned in favour of safer methods. Two of the largest deposits are unfortunately of very moderate grade, and hence have so far been little worked. No doubt, advantage will yet be taken of them when more systematic grading and dressing is adopted. Four consignments, aggregating 800 tons, from the deposits opened to the date above quoted, yielded from 49·8 to 56·5 per cent. of sesquioxide of chromium. By careful blending a considerable quantity of the abundant lower grade ore could be worked in with the first grade, and a uniform percentage of, say, 50 per cent. maintained.

The ore in this mine was conveyed by gravity from the mountain on a wire rope to the opposite side of the Murrumbidgee River, the bags of ore being suspended by hooks with running blocks.

Shoalhaven.—A sample of chromite, assaying 49·55 per cent., was received as coming from the above locality, but its correctness is very doubtful.

Stony Batta, County Hardinge.—Chromite reported. No particulars.

Tamworth District.—From 20 miles north, 26 miles north-west at Hall's Creek, and from Manilla Range, samples of chromite have been received, yielding from 40·41 to 46·59 per cent.

Tumut District.—See Darbalara, Wagara, Brungle, and Wiangle Parishes, County Buccleugh.

Uralla.—

*Vulcan Mine**, *Mooney Mooney Range, 4 miles north-easterly of Coolac Railway Station.*—As already stated, the group of deposits at the site of this mine were the first opened in the Gundagai district under the name of Wright's Mine. At the time of my first inspection in 1892†, a little surface prospecting or uncovering had been done. The largest deposit thus exposed was about 63 feet by 12 feet at the greatest width, to a depth of 10 feet. The average width of chromite was about 7 feet. About 2 chains further down the slope of the hill another deposit, partly exposed by shallow openings, measured 45 feet by 5 feet. Selected samples from the two outcrops yielded 47·68 and 48·00 per cent. Cr_2O_3.

Estimates of the probable quantity of ore available in these deposits, based on the supposition that they were lens-shaped, and that the vertical extension might be assumed to be equal to about half the horizontal (owing to weathering of the exposed surface) tallied very closely with the actual amount won during mining operations. At the time of my second visit in February, 1895, about 1,200 tons had been raised and dispatched; and, judging from the appearance of the dangerous open workings—which were just then being abandoned on account of risk—the total output would be in the neighbourhood of the former estimate, viz., 2,250 tons.

Wagara Parish, County Buccleugh.—See Kangaroo Mine.

Walcha District.—A sample of chromite submitted from this district assayed 48·26 per cent.

Wallendbeen.—See Berthong.

Welch's Mine.‡—In Portion 173. On the west side of the continuation of the serpentine range, south of Adjungbilly Creek, Messrs. Welch and Springthorpe extracted 220 tons from a deposit, which gave out abruptly, and was abandoned.

Wright's Mine.—See Vulcan.

Wyalong (near).—A sample submitted for assay purported to be from this district, but the information is doubtful. It assayed 37·35 per cent.

Wyangle (Parish of).—See Brungle Creek.

Young District.—Chrome occurs about 20 miles from Young. A little attention has been given to it, and a number of assays made, ranging from 42·46 to 48·35 per cent.

Yulgilbar, Clarence River.—Chromite has been examined which was reported to have come from the ranges between Solferino and the local Cinnabar Mine; and as serpentine occurs in this locality, the report is probably correct.

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* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1892, p. 154. J.E.C., *Ibid*, 1895, p. 125.
† J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1892, pp. 153–9.
‡ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126.

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.
No. 2.

NOTES

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OCCURRENCE OF TUNGSTEN ORES IN NEW SOUTH WALES,

WITH A

REGISTER OF LOCALITIES.

BY

J. E. CARNE, F.G.S.,

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Notes on the Occurrence of Tungsten Ores in New South Wales;

WITH A

REGISTER OF LOCALITIES.

By J. E. CARNE, F.G.S.,
Geological Surveyor.

Reviewing our knowledge of the local occurrences, it must be admitted that no payable deposits have yet been discovered, notwithstanding the stir caused by the sudden large advance in values of tungsten ores about the year 1890, although numerous fresh occurrences have been noted, and previously known ones more or less superficially explored.

Judging from the known deposits of tungsten ores in this Colony, and from the extremely limited outputs recorded in the statistical returns of countries producing them, notwithstanding the constant demand, it would appear that the ores of this metal are sparsely distributed in nature.

The chief supplies appear to be drawn from Cornwall (England), Austria-Hungary, Germany, and Saxony. Texas and Northern Mexico are reported this year to be offering unusually large quantities from recently-opened mines.*

The following outputs, recorded from the first-mentioned countries, are taken from "Mineral Industry," 1896 †:—

1891–5.	United Kingdom ...	289 tons	(returned marked *nil* for 1894–5).
1891–5.	Austria-Hungary...	247 „	
1891–5.	Saxony	226 „	
1891–4.	Germany	208 „	(mixed Wolfram and Uranium ores).

In the "Mineral Industry of the United Kingdom, 1895, Second Annual Report," Portugal and Spain are also recorded as producers of tungsten ores to the extent of 19 tons and 14 tons, respectively, in 1894.

The above quotations serve to exemplify the very restricted world-production of tungsten ores, and explain the reason of rapid advance in value as fresh uses are discovered for the metal or its salts.

Prior to 1890 the market value of tungsten ores did not exceed about £12 per ton. In that year Messrs. Sternberg and Deutsch, of Martinikenfelde, *via* Berlin, made personal inquiry for wolfram in the New South Wales Court at the London Mining Exhibition, and offered £30 per ton for

* Extract from an official letter from F. E. Clotten, 136, High-street, Cologne, Germany.
† The Mineral Industry: Its Statistics, Technology, and Trade, 1896, v, pp. 749, 771, 776, 819.

ore containing 70 per cent. tungstic acid, delivered in Berlin. This first intimation of rapid advance in value was announced in the Colony through the Department of Mines, and resulted in considerable activity in prospecting for this mineral. Prices have receded since that date. The present value for 70 per cent. ore may be accepted as about £20 per ton, bagged, free on board, at Sydney, with an advance of 5s. 3d. per unit above 70 per cent. These quotations are from Mr. Clotten's letter already referred to. The English value for production in 1893 equalled about £19 per ton.

The high minimum market grade—viz., 70 per cent. tungstic acid—requires ore entirely separated from gangue; indeed, some wolfram ore, to all appearances clean, falls below this standard. Dressing to standard by cobbing and hand-picking is not a difficult matter when the ore is in fairly large clean bunches; but in the case of small particles or crystals distributed through the gangue, which is usually quartz, separation would be almost economically impossible, under the local conditions of mining and dressing, owing to the heavy loss entailed by the brittleness of wolfram (which is the chief ore), arising from its facile cleavage into extremely fine plates. The reduction of the quartz gangue by stampers or rolls to the requisite fineness to free the ore particles would slime most of the wolfram and necessitate an extensive recovery plant. If lower grade ore was saleable, possibly miners could obtain more remunerative returns from proportionately lower selling values.

Until recent years the principal use of tungsten was in the preparation of acid salts for rendering coloured cotton goods "fast," or washable, and linen and cotton theatrical or other properties non-inflammable, and in the manufacture of stained and other papers, &c.

Its chief value, however, at the present time is as an alloy in the production of certain classes of steel for artillery and tool purposes. There is, however, considerable diversity of opinion amongst authorities as to the special qualities or merits of tungsten steel, some affirming and others denying its brittleness and hardness.

Professor F. L. Garrison discusses this question in an interesting article on "Alloys of Iron and Tungsten," * and quotes Metcalf, from the "Transactions Am. Soc. C.E.," Vol. XXVII, pp. 394-5, and H. M. Howe's "Metallurgy of Steel," p. 82, for the following statements:—"It is popularly believed that tungsten renders iron very hard, and in support of this is the fact that there are many brands of so-called self-hardening steel on the market—that is, steel which does not require to be rapidly cooled in order to become hard. Nevertheless, this belief is erroneous; for if a steel be chosen not excessively high in manganese and carbon, as all the self-hardening specimens are, then no amount of tungsten will make it file-hard if allowed to cool spontaneously in the air. The true function of this element is to delay the rate of change of carbon when either going in or out of solution. . . . . Tungsten steel is neither so hard nor so strong as plain carbon steel; hence there is no advantage in using it except for certain purposes."

Professor Garrison remarks that Metcalf has also referred to tungsten in steel as acting merely as a vehicle in enabling the carbon to carry the "temper" or "hardness." He further observes that this peculiarity is only developed in the presence of manganese.

Howe states that "the hardness of tungsten steel is not impared by heat, and as a consequence may be driven much faster than carbon steel when used as machine cutting tools."

* Ann. Rept. U. S. Geol. Survey, 1894-5, xvii, pt. 3, pp. 615-623.

"Tungsten steel appears chiefly adapted for cutting tools of lathers and planers."*

"When forged red-hot and slowly cooled, tungsten steel is reported to possess an extraordinary degree of hardness, which, however, gives way to softness when plunged red-hot into cold water, quite contrary to most other species of steel."†

E. Fuchs and L. De Launay state that "Tungsten has for some time been used to a considerable extent in the manufacture of steel, particularly for artillery, and this use is restricted only by the rarity of the metal itself."

"In a series of experiments made by Captain Caron, the addition of tungsten to cast-iron (⅛ to 1 per cent.) increased the hardness and the tenacity of of the metal in proportion to the weight of the tungsten added. . . . But it is especially in the case of steel that tungsten in very small proportions increases the hardness and tenacity."

"This influence of tungsten on steel and iron tends to prove that it neutralises the contained phosphorus, sulphur, and arsenic, combining with them chemically. In cast iron it is reduced at the expense of the carbon, and adds, more or less, to the metal the character of steel."‡

Tungsten ores are most frequently associated with tin and bismuth ores, and, as before stated, the principal supplies are drawn from tin workings. In fact, in some countries and provinces—Saxony, for instance—the waste from ancient tin-dressing floors has been carefully worked over for the discarded wolfram of earlier mining days. In others wolfram has become the most important product of previous tin mines.

Intimate mixture with tinstone, either in the form of fine worn grains in alluvial drifts, or as finely comminuted particles in crushed lodestuff, necessarily depreciates the value of each mineral owing to the difficulty of separating, arising from practically equal specific gravities.

In tin smelting the presence of tungsten is objectionable in any proportion. Dr. G. Mackenzie, Manager of the Sydney Tin Smelting Works, informs me that the maximum quantity of tungsten ore which may be disregarded in tin smelting should not exceed 1 per cent.

The effect of tungsten in tin-smelting furnaces is to impede reduction and cause loss by scorification.

When possible separation of wolfram from tinstone is effected by cobbing and hand-picking; in finely comminuted material, however, fusion with common soda or sulphate is resorted to for the purpose of forming a soluble tungstate of soda which can afterwards be removed by washing.

Tungsten ores consist of compounds of tungstic acid with iron and manganese (wolfram, etc.), lime (scheelite), lime and copper (cupro-scheelite), and lead (stolzite). Of these wolfram and scheelite are the most common, and wolfram the most important commercially. In addition to the above are several alteration products of less importance.

The percentages of tungstic trioxide (tungstic acid), on which the market value depends, range up to about 77·5 in wolfram ores, and 80 in scheelite.

Tungsten ores have been recorded from the following localities within the Colony, many of which are known officially, others, however, are dependent upon the good faith of persons desiring assays made in the Departmental Laboratory.§

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* H. M. Howe, Metallurgy of Steel, p. 82.
† Trans., Am. Inst. Mg. Eng., xxii., p. 236-245.
‡ Trai et des Gites Mineraux et Metalliferes, ii., pp. 169 and 170.
§ For many of these localities I am indebted to the valuable register compiled by Mr. Trickett, of this Branch.

REGISTER OF LOCALITIES.

Adelong.—Professor Liversidge gives the following description of scheelite from this locality :—*" A specimen from the Victoria Reef Gold Mine, Adelong, County Wynyard, was massive, but with a portion of a crystal showing on one side, of an amber colour, translucent, resinous lustre, brittle, splintery fracture. Hardness, 4·5 ; specific gravity, 6·097. Associated with a dark green chloritic veinstuff. The following analysis was kindly made for me by Dr. Helms :—

Loss at red-heat	·25
Tungstic acid	79·53
Lime	19·14
Alumina	·58
Magnesia	·07
	99·57

The above results correspond to the formula $Ca.\ WO_4$."

Armidale District.—From Gara Falls, about 12 miles from Armidale, a sample of scheelite was assayed in the Departmental Laboratory, in 1886, for a yield of 47·9 per cent. of tungstic acid. A sample in 1894, from the same district, yielded 66·29 per cent.

Berridale.—About 20 miles S.W. of Cooma.—Mr. Warden Love reported, in connection with the discovery of this locality, " A broken outcrop of quartz, containing wolfram, was traced for 100 yards, running east and west. An assay of a small sample yielded 69 per cent. of tungstic acid."† (D.M.A., 1891.)‡ Another assay was made in 1893, yielding 54·35 per cent. (D.M.A., 1893.)

Bingera.—Wolfram forwarded as coming from this locality yielded 72·46 per cent. tungstic acid. (D.M.A., 1893.)

Bundarra, 25 miles S.W. of Tingha, New England.—A sample received from this locality consisted of wolfram associated with arseniate and arsenide of iron in quartz, which yielded 44·94 per cent. of tungstic acid. (D.M.A., 1891.)

Burrowa District.—Both scheelite and wolfram occur in the neighbourhood of Frogmore, associated with both quartz and granite. Assays have yielded from 31·65 to 66·96 per cent. of tungstic acid. (D.M.A., 1891–2–3.) Prospecting failed, however, to discover any payable deposits.

Casino District, Richmond River.—From this district a sample of scheelite was assayed for a return of 75·30 per cent. of tungstic acid. (D.M.A., 1895.)

Clive County, Parish of Bengha.—Wolfram in a siliceous gangue, stained with arseniate of iron, forwarded from this locality yielded 42·55 per cent. of tungstic acid. (D.M.A., 1892.) It is also reported from Scrubby Rush, in the same County.

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* Minerals of New South Wales, 1888, p. 85.
† Ann. Rept. Dept. Mines and Agric. for 1891.
‡ Note.—Assays made in the Departmental Laboratory are marked D.M.A.), with the year.

Cobar District.—Wolfram in quartz forwarded from this District yielded 53·70 per cent. of tungstic acid. (D.M.A., 1895.)

Cowra District.—Wolfram, yielding 67·80 per cent. tungstic acid, was forwarded for assay from this locality in 1893. (D.M.A., 1893.)

Cooma, 3 miles from.—Probably this locality should be Berridale. Wolfram reported as coming from near Cooma, yielded 54·95 per cent. tungstic acid. (D.M.A., 1891.)

Cordillera Hill, Tuena District.—Scheelite, cupro-scheelite and stolzite were discovered when opening the Cordillera Hill Silver and Copper Mine in 1888, but, so far, the above minerals have not been systematically searched for.

The Government Analyst, Mr. W. H. Hamlet, F.C.S., &c., for this Department made the following analysis of a massive sample of a dark greenish colour* :—

Tungstic trioxide	69·31	per cent.
Lime	19·35	,,
Silica	4·88	,,
Copper oxide	4·05	,,
Iron oxide	2·01	,,
	99·60	

Prior to this date, Mr. W. A. Dixon, F.I.C., F.C.S., detected the presence of stolzite (tungstate of lead) in this mine. Stolzite is also recorded from Broken Hill.†

Deepwater, New England.—Both wolfram and scheelite occur in the Bolivia district, the particular localities specified being Nine-mile, 10 miles east, and 20 miles from Deepwater, at Bald Rock; at the latter it occurs in quartz and felspar stained with arseniate of iron. At 10 miles east of Deepwater, ilmenite is associated with the wolfram in quartz. Assays from the above localities, made in the Departmental Laboratory in 1892–3–4, yielded from 47·02 to 73·10 per cent. of tungstic acid.

Ding Dong.—Between Deepwater and the Great Divide.—The late Government Geologist, Mr. C. S. Wilkinson, recorded the occurrence of wolfram at Ding Dong, where it is associated with tinstone in griesen.‡

Emmaville, New England.—Mr. T. W. E. David, B.A., F.G.S., thus refers to the occurrence of tungsten ores in this district:—"An important vein of wolfram occurs on the Mole tableland, 13½ miles north of Emmaville in a direct line, but 21 miles distant by road. The point, at which the reef was observed to be rich in wolfram, bears west 36° south from the south-west corner of portion 407, parish Rockvale, county Clive, a quarter of a mile distant, and lies just outside the boundary of this parish, in the north-east corner of parish Flagstone, county Gough. The vein is, in places, from 10 to 12 yards wide, though probably not metalliferous throughout its entire width. Owing to the reef being covered over with iron-stained sandy soil, it is impossible to ascertain, by mere inspection, the average width or length of its outcrop, though surface indications favour the supposition that the reef is a strong one. The strike is about N. 40° E. As far as I am aware, this reef has never been prospected, and it is situated partly on Crown lands.

* Ann. Rept. Dep. Mines for 1886, p. 41.
† Records Geol. Survey N. S. Wales, 1896, v, pt. 1, p. 8.
‡ Ann. Rept. Dept. Mines for 1883, p. 151.

"Wolfram also occurs at the Gulf main vein, Hall's Grampians, Lee's Gully, and the Planet Mine, near the head of the Nine-mile Creek, parish Wellington Vale, county Gough.

"Scheelite has been found in small quantities at McDonald's veins, on the Glen Creek. The mineral is honey-coloured and translucent."*

Though it is understood that no very large amount of prospecting has been done on the Mole Tableland lode, yet there is sufficient to reveal the fact that the wolfram is confined to comparatively small bunches in the reef, though at the same time larger than any other known deposits of clean ore. There is no record of any assays in the Department from this locality, but from physical appearance, the ore is of first quality.

An assay made, in 1892, of rubble wolfram in quartz and mispickel from the Emmaville district yielded 64·06 per cent. of tungstic acid.

Elsmore, near Inverell.—A sample of wolfram in quartz from this locality yielded 67·20 per cent. of tungstic acid. (D.M.A., 1895.)

Frogmore, Burrowa District.—See Burrowa.

Glen Innes.—Mr. C. S. Wilkinson recorded the occurrence of wolfram, associated with bismuth, molybdenite and arsenical pyrites, in Portion 25, about half a mile north-west of Kingsgate, in a large pipe vein, consisting of a very ferruginous mass of quartz.

About 12 miles north from Glen Innes at Hogue's Creek, about 1 mile from the Tenterfield Road, Mr. Wilkinson described a larger occurrence of wolfram associated with the minerals already mentioned as present in the Kingsgate ore. He described the mode of occurrence as follows:—

"They form irregular veins and masses of quartz traversing a fine-grained micaceous felsite rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length about 100 yards and a width of 15 yards, is traversed by a network of quartz veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore, molybdenite, arsenical pyrites, and wolfram.

In another place, about 100 yards from the last-named, a mass of hard crystalline quartz, in size at the surface about 40 feet by 20 feet, has been opened for a few feet in depth. It contained bismuth and tin ores, together with a large quantity of wolfram."†

Mr. Wilkinson did not consider that the lodestuff could be profitably worked for tin ore owing to the large proportion of wolfram.

Quite recently Mr. C. S. McGlew has been opening up this deposit of wolfram. A certain amount of clean wolfram is obtainable, but the bulk of the lodestuff, so far as operations have yet extended, is much below the minimum grade.

Gara Falls.—See Armidale.

Grampians (Hall's).—See Emmaville.

Gulf Mine.—See Emmaville.

Gundagai.—Wolfram in granite, forwarded from the Gundagai District, was assayed for a yield of 61·44 per cent. of tungstic acid. (D.M.A., 1892.)

Guyra.—Scheelite from this locality yielded 75·60 per cent. of tungstic acid.

* Geology of Vegetable Creek Tin-mining Field, 1887, pp. 161-2.
† Ann. Rept. Dept. Mines and Agric. for 1888, p. 154.

Hillgrove, Armidale District.—Scheelite was noted at Hillgrove shortly after the gold discovery, because of its association with the gold and stibnite of the reefs. No appreciable quantity has, however, been exposed in the extensive workings and prospecting of the locality. Assays made of a number of samples during 1892, 1893, and 1894, yielded from 38·25 to 71·80 per cent. of tungstic acid. The gold and antimony reefs of Hillgrove occur principally in slate country close to the junction of granite, and to a lesser extent within the granite also.

Inverell.—Professor Liversidge gives the following description of a sample of wolfram from Inverell:—

"A specimen found in quartz veins with tinstone, Inverell, county Gough, of the usual bronzy black colour, sub-metallic lustre, opaque, lamellar structure, with only traces of crystal faces, had the following composition:—

Tungstic acid	77·640
Iron protoxide	18·760
Manganese	4·121
	100·521*

Another sample recorded in the Departmental Assay Register as coming from 15 miles south of Inverell, yielded 73·40 per cent. of tungstic acid.

Jingellic, Upper Murray River.—Mr. E. F. Pittman recorded the presence of wolfram in the Jingellic tin lodes, which consist of quartz veins in granite. In No. 4 lode, which had been opened for 8 chains, the associated minerals were much arsenical pyrites, some wolfram and tourmaline, and a good percentage of tin ore.†

The tin lodes at Jingellic were abandoned shortly after Mr. Pittman's inspection owing (according to local report) to the failure to realise on some 9 tons of ore extracted, which may probably have been due to the presence of wolfram beyond the minimum limit of Australian smelters.

Mila, 14 miles south of Bombala, Monaro.—Wolfram occurs very sparingly distributed in a quartz reef in Mr. Cochrane's property, near Mila.

Mole Tableland.—See Emmaville.

Mount Hope.—North-west of Euabalong, Lachlan River.—Wolfram was discovered near Mount Hope by a Mr. Eason about the time of the gold discovery at Mount Allen in this neighbourhood. Several assays have been made which yielded from 62·57 to 72·2 per cent. of tungstic acid (D.M.A., 1892), but nothing is yet known of its mode of occurrence or probable quantity.

Mount Sutton, New England.—An assay sample from this locality yielded 71·22 per cent. of tungstic acid.

Nangeribone Run, via Nymagee.—Wolfram was detected in a sample of quartz from this locality, sent to the Department for examination.

New England.—Under this very broad definition of locality several samples of wolfram have been assayed in the Departmental Laboratory for yields from 56·50 to 70·75 per cent. of tungstic acid.

Newstead.—Wolfram from this locality has been noted, but nothing definite is known either of the exact locality or mode of occurrence.

* Minerals of New South Wales, 1888, p. 85.
† Ann. Rept. Dept. Mines for 1881, p. 143.

Pulletop Station, County Mitchell, Wagga Wagga District.—Wolfram occurs in the vicinity of Pulletop Creek in the Parishes of Westby and Barrandana, associated with tinstone in quartz veins close to the junction of slate and granite, and in drift originating fron denudation of the reefs. At the time of my inspection of this locality in 1894, about twenty loads of drift were run through a box-sluice for a yield of 5 or 6 cwt. of mixed wolfram and tinstone, an average assay of which yielded :—

	per cent.
Metallic tin	27·72
Tungstic acid	28·82*

A mixture of this character is unsaleable in the Colony, and owing to the practically equal specific gravities, the two minerals cannot be separated by mechanical appliances, though a large proportion of the wolfram could be removed by sieving, owing to the fact that all the larger fragments consist of that mineral, the tinstone being comparatively fine.

After considerable inquiry abroad, Messrs. Harrold Brothers, of 19, Bridge-street, Sydney, who were devoting considerable attention to the subject, ascertained that the mixture represented by the above assay had a prospective value in England of about £15 per ton, less about £3 cost of treatment.

Assays of other samples from Pulletop, made in 1894, yielded from 45·90 to 62·20 per cent. tungstic acid.

Purnamoota, Barrier Range.—A sample from this locality, received during the current year, was tested in the Departmental Laboratory for a return of 62·10 per cent. of tungstic acid.

Peelwood.—Scheelite has been reported from this locality. It is, however, more than probable that the occurrence recorded under this heading is identical with that of Cordillera Hill.

Severn River, near Emmaville.—Wolfram is recorded from this locality in 1886, which yielded, on assay, 74·41 per cent. of tungstic acid.

Tenterfield District.—Granular wolfram in clayey matrix, from this district, was assayed in 1893 for a return of 57·25 per cent. tungstic acid; and another sample, more specifically defined as coming from within 7 miles of Tenterfield, yielded 40·21 per cent.

The Gulf, New England.—See Emmaville.

Waukeroo, Barrier Range.—Wolfram is recorded from this locality, but no assays have been registered.

Wellington Vale.—Vegetable Creek or Emmaville district, which see.

Yeoval.—South-west of Wellington.—Cupro-scheelite was identified by Mr. G. W. Card, A.R.S.M., Curator, amongst specimens collected from Yeoval by Mr. E. C. Whittell, Field Assistant.†

* Ann. Rept. Dept. Mines and Agric. for 1894, p. 113.
† Ann. Rept. Dept. Mines and Agric. for 1896, p. 143.

Sydney: William Applegate Gullick, Government Printer.—1898.

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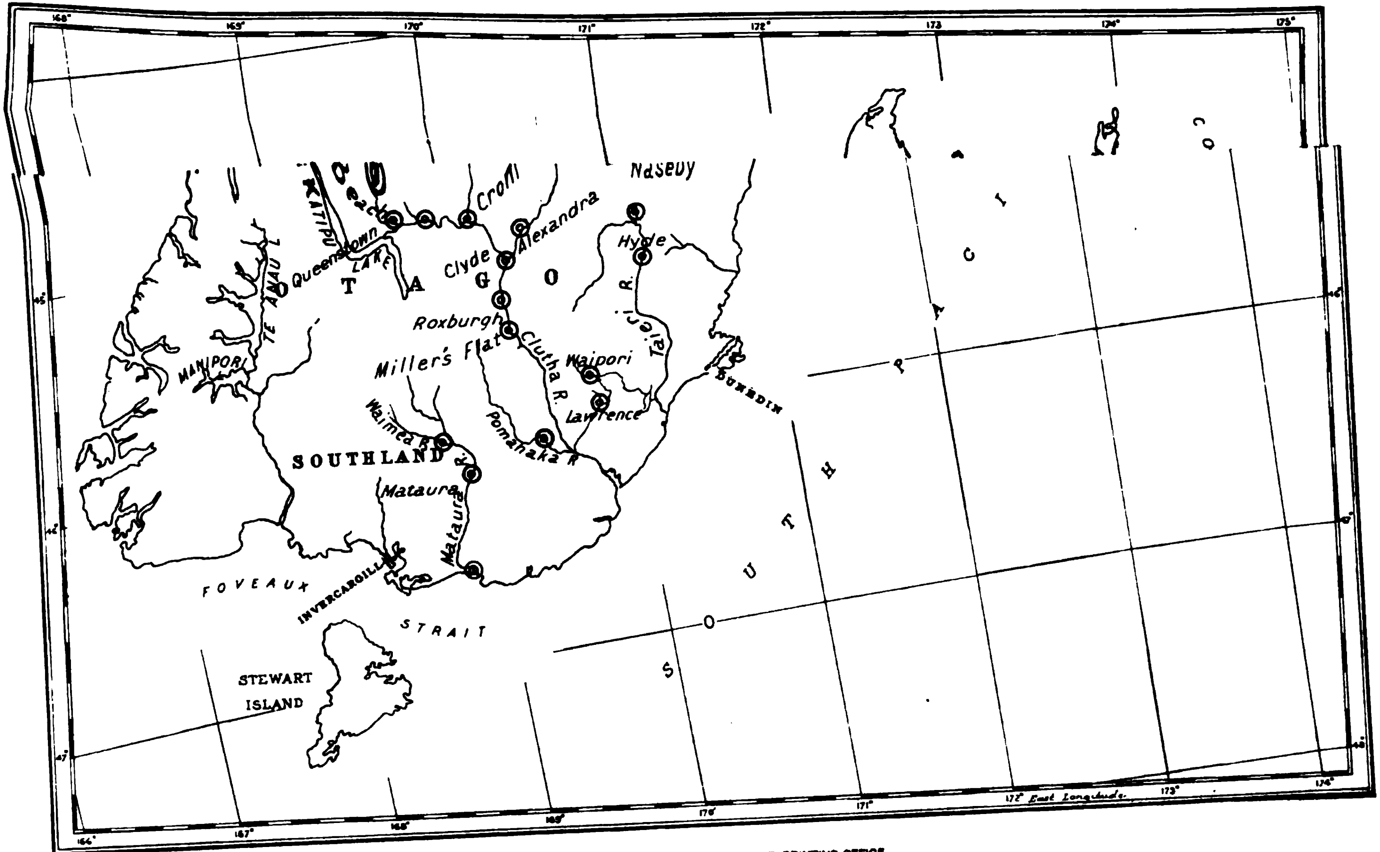

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NOTES ON GOLD DREDGING

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MINERS accustomed to exploit the gold-bearing gravels upon river-banks, and tantalised so often by being obliged to cease following some rich "run" of ground on account of it having dipped underneath the stream, have always desired a method which would enable them to baffle the water and prosecute their industry upon the river-bed. They may frequently be seen to look with longing towards the rich treasure which they believe to lie concealed there.

A consideration of the general geology of river-basins would seem to encourage them in this view, and tends to show that the submerged gravels should certainly be as rich, if not richer, than any found elsewhere in the valley. In many valleys we have evidence of the number of times the river has changed its course in the deposits of gravel and other detritus which are situated at various distances from the flowing water. The extent of these deposits, the altitude at which they occur, and calculations as to the rate of erosion, enable us to relatively measure, or at any rate form some rough idea of, the age of the river; and upon these data geologists have come to the conclusion that many streams have been flowing over constantly changing courses for immense intervals of time. The process of building up a gravel bed is no sooner completed than that of decay commences. The disintegration may take place rapidly, as when the erratic river returns once more to one of its old courses, or it may take place so slowly as to be scarcely noticeable within a man's lifetime. However, it is always going on, and after a certain interval has elapsed—it may be many thousand years—the constituents of every bed will be once more travelling down the river to a new resting-place, and finally a new cycle of changes will commence.

Now, I think it will be apparent that I have been describing a natural process of sluicing. The miner will recognise that the crumbling beds of stranded detritus represent the ground in the face of his claim, and that the river may be looked upon as a great sluice-box. He will understand why, as a general rule in the case of auriferous drifts, the younger beds in the valley are richer than the older ones, and why we should look for the richest ground in the river itself where the youngest deposits of all are to be found.

Before the practice of dredging was introduced, it was only possible to win the gold from those portions of the river-bed from which the water could be diverted. Sometimes the stream was confined within smaller limits by means of a wing-dam; or a spot would be selected where the river flowing back on itself formed a "horse-shoe bend," so that the whole of the water could be diverted from a portion of the bed by means of a tunnel driven through the narrow neck of land.

The industry originated and has been brought to its present state of perfection upon the Clutha River, in the province of Otago, New Zealand. It has made considerable progress within the last few years, and has done much towards creating an era of increased prosperity in the province. Many mining townships which were ailing a short time ago, on account of gold-getting from ordinary sources having decreased, have had new life infused into them, and have once more become important centres of activity. A large amount of employment at good wages has been found, both for dredge-hands and mechanics, the latter being engaged in manufacturing and repairing dredges in the Dunedin workshops. About fifty dredges are now at work upon the Clutha and its tributaries.

I intended to have given particulars of the gold yields obtained by the various companies who publish returns. I find, however, that many of the most successful machines are privately owned, and no returns are available, so to do this would be to convey a wrong impression altogether as to the magnitude of the industry. A few remarkable yields recently obtained, and selected at random from those which came under my notice, will show how quickly the capital sunk in the industry has been in some instances recovered. The Electric No. 2 dredge, working near Cromwell, which cost £5,000 to build and launch, obtained more than this amount of gold within seven weeks after she started to work. A small "current-wheel" machine, working about a mile below Alexandra, obtained gold to the value of £3,570 during two months of last winter. The "Moa," belonging to the Clyde Dredging Company, Limited, a company which has only a capital of £4,000, for nine months' work, ending in September last year, obtained gold to the value of £10,156.

The quantity of gold which escapes the well-equipped modern dredge is small, and it is not possible under ordinary circumstances to profitably rework ground, so we may expect the rich bed of the Clutha to be worked out in a few years' time. However, the dredging industry will not cease with the exhaustion of this treasure. To such a state of perfection has it been brought that ground containing only a grain or a grain and a half of gold per cubic yard can now be worked at a profit; and, moreover, under certain conditions a dredge is able to cut a channel for itself through the river-bank and wander at the will of the engineer in charge over the bordering flats; or it may be launched to work low-lying auriferous flats, far removed from any river at all. Under the new conditions the yields of gold are not likely to be so sensational, but they will probably be more regular than they have been in the past.

A sketch map of the Middle Island of New Zealand will be found facing the first page of this paper, upon which the localities where dredging operations have been carried out are indicated.

The Clutha River.

The Clutha, also called Molyneux, carries down to the sea an enormous volume of water. "In 1864 the Provisional Government had the volume of the river carefully measured at a time when its waters were low, and the result was found to be something extraordinary, being not less than 1,690,400 cubic feet per minute. The following comparison with other large rivers was published at the time:—

	Cubic ft. per min.
Molyneux	1,690,400
Tay	274,000
Boyne	180,000
Thames	102,000
Clyde	48,000
Rhine	3,960,000
Rhone	649,000
Tiber	618,000
Saone	460,000
Arno	266,000
Nile	1,386,000
Irrawaddy	4,500,000

Thus the Clutha River, when at its lowest, was found to be larger than the Nile, six times the size of the Tay, nine times that of the Boyne, and sixteen times that of the Thames."* More recently, the late inspecting engineer, Mr. H. A. Gordon, has estimated the discharge of the Clutha as follows:—

	Cubic ft. per min.
Minimum	837,000
Maximum	5,040,000
Average	1,674,000

Being chiefly dependent upon the snows of the Southern Alps for its supply of water, the flow is consequently greatest during the summer months, and reaches a minimum in winter.

The Clutha itself heads from Lakes Wanaka and Hawea, and its chief tributary, the Kawaru, from Lake Wakatipu. These three lakes play an important part in the economy of the river. They cover in the aggregate an area of 237 square miles, and, by acting as reservoirs, regulate the flow and prevent floods occurring. The fall of the river from its source in Lake Wanaka to the sea averages about 10 feet per mile, and the current is for the most part very rapid.

The country upon the banks varies greatly in character. Here the water tumbles impetuously through a rocky gorge, where the mountains rise abruptly on either side, and elsewhere, it will flow, still travelling hurriedly, through extensive low-lying flats. The dominant rocks are contorted and much altered slates and schists, of Palæozoic age, which are overlain in places by horizontally bedded clays and sandstones. Interstratified with the latter rocks are beds of lignite. Central Otago is absolutely devoid of timber, and, by providing a cheap fuel for steaming purposes, these lignite beds have greatly assisted the dredging industry.

There are many auriferous rivers in Australasia, yet for a number of years has the practice of dredging been practically confined to the Clutha and its tributaries, and the question will arise: In what way does this New Zealand river differ from the others, and how is it better adapted for this method of gold-winning? As regards its swift current and large volume of water, the Clutha is certainly far ahead of other rivers in these colonies; it is also probably unique as regards the extent, richness, and general arrangement of its submerged gravels. There is, however, much to show that the first-mentioned characteristics have, on the whole, tended to retard rather than

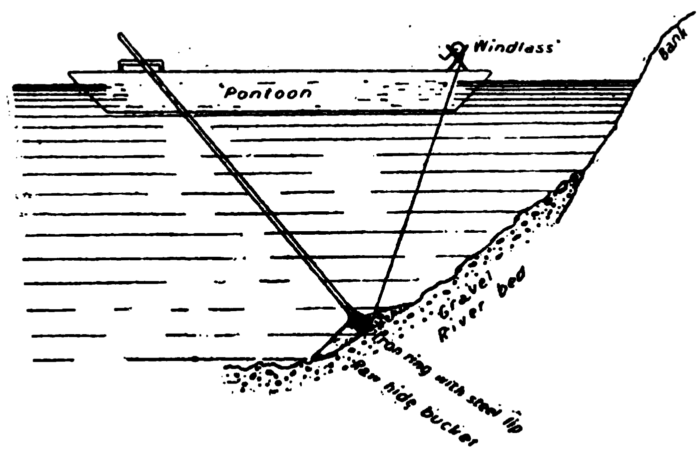
* Handbook of New Zealand Mines, Wellington, 1887, p. 38.

assist the industry. The best results have been obtained during the winter months, when the volume of water is at a minimum; indeed, many dredges are obliged to suspend operations altogether in summer. It is true, as I shall point out elsewhere, that, at one period in the history of the industry, the swiftly flowing water may have rendered good service by supplying power. Again, it may be of assistance in taking away the tailings. Yet it should be remembered on the other hand that a flow strong enough to carry off the tailings astern will also bring down silt from above, and deposit it in the "paddock" where the buckets are at work. When I was inspecting the Shotover River, a warm night, by accelerating the rate of melting of the snows upon the mountains, produced a slight fresh, and one of the dredges had to cease work for twelve hours, owing to the silt being deposited at a greater rate than it could be elevated. The best use is made of the current when the dredge can be moored, so that the buckets excavate into the bank or under still water, and only the elevator or tailings-shoot projects over into the running stream. The modern dredge certainly works to greater advantage in still shallow water, always provided that there is sufficient water to float the machine and wash the elevated gravel.

On the whole, I think the leading position occupied by the Clutha must be ascribed to its great wealth in alluvial deposits, and to the fact of the industry having been cradled and perfected upon its waters.

THE EVOLUTION OF THE MODERN DREDGE.

Spoon Dredges.—These primitive machines have been employed upon the Clutha ever since 1864. Their remains are to be seen in many places upon the river banks. They have also been occasionally used upon the Macquarie, and other rivers in our Colony. The sketch below is the outcome of descriptions given to me by miners and others.



The contrivance consisted of a long spar, terminating in an iron hoop, which supported a cow-hide bucket, capable of holding about a third of a ton of gravel. The spar swung upon a pivot placed near the stern of the pontoon, and was raised and lowered by means of a windlass erected in the bow. The dirt was emptied out of the bucket on to the deck, and was afterwards washed in an ordinary miners' cradle.

A spoon dredge, even under the most favourable conditions, could only treat 2 or 3 tons of gravel per hour, as against the 100 tons which the modern steam dredge is capable of dealing with in the same period. Nevertheless, in the early days of gold-mining upon the Clutha, when the virgin ground in the river was not buried beneath vast deposits of tailings, as is the case to-day, good results were obtained, and not a few small fortunes built up as the result of the operation of these machines.

Current-wheel Dredges.—The next dredges placed upon the river lifted the gravel with a chain of buckets, and being provided with undershot wheels, derived their power from the river current (*see Plate VII*). The buckets discharged into sluice-boxes, which were supplied with water by a centrifugal pump. One or two of these machines are still upon the river, and from time to time do good work. The advantages which they possess as compared with steam dredges are as follows:—(*a*) Small first cost; (*b*) no fuel is consumed; (*c*) fewer hands are required. They labour, however, under one great disadvantage—being dependent upon the current for power, they are always obliged to keep well out in the stream, where during a considerable portion of the year the water may be too deep, or the deposit of silt too great, to permit of work being continued.

Steam Dredges were first launched upon the Clutha in 1881. They only differed essentially from the machines then upon the river in being provided with boiler and engines. They are able, when the river is high, to work along the bank or, by running up into the eddies and backwaters, in places where a minimum amount of silt is being deposited. Hence, with the introduction of steam, stoppages have been of shorter duration, and work has proceeded more regularly.

The introduction of a tailing-elevator.—When a dredge is working in still water there is always a tendency for the tailings to find their way back again into the excavation being made by the buckets. In designing the first machines endeavour was made to overcome this evil by raising the top tumbler, and causing the dirt to be discharged at as high an elevation as possible, so that sufficient fall might be obtained to permit of a long shoot being carried over the stern, by means of which the tailings could be discharged at some distance behind the pontoon. The limit to which it is possible to elevate in this manner is soon reached; and, moreover, the adaptation of this method tended to impair the general efficiency of the whole machine.

The difficulty was eventually overcome by lifting and stacking the tailings from the stern of the dredge by means of a bucket-elevator. The improvement was first applied by Messrs. Cutten Brothers, of Dunedin, to the "Enterprise" dredge (Plate VI), which was employed in working a beach upon the Clutha, near Alexandra. It may be said to have effected a revolution in the industry. The old machines were obliged to confine their operations to the rivers; the new ones, armed with an elevator, have been successfully employed in exploiting low-lying auriferous flats.

Sand pumps.—Attempts have been made to exploit the gravels of the Clutha River by means of suction pumps, but in every instance have failed. Similar results would seem to have been obtained in Montana, United States of America, where these machines were tested prior to the introduction of bucket-dredges.

The machines consisted essentially of a pontoon supplied with a powerful pump, which delivered its contents into sluice-boxes. As an instance of the costliness of the process, I may mention that a suction dredge working upon the Waiparapa Beach, near the mouth of the Mataaura River, was found to require 60 I.H.P. to lift on an average 15 tons of gravel per hour whereas a bucket-dredge of 30 I.H.P. would lift many times this amount in the same time.

General Description of a large Dredge.

The tendency at the present time seems to be to build larger machines. The initial cost under these circumstances is greater, and more fuel is consumed; but on the other hand, the cost for labour is the same as on a smaller dredge, and an increase quantity of gravel is treated.

The Electric Company's No. 3 *Dredge.*—This machine was being built at the period of my visit. When completed, it will be the largest dredge employed in gold-winning in New Zealand. It is expected that it will be launched in about five months' time to work ground upon the Kawarua River, about 3 miles above Cromwell. The pontoons are 120 ft. by 10 ft. by 7 ft., and are built in one piece. The well hole is 88 ft. long by 5 ft. wide. The deck beams project 2 ft. 6 in. on either side, so that the deck will be 30 ft. wide. The planking is kauri; the frames Tasmanian hardwood; and the stringers ironbark. The ladder will be 75 ft. long. The bucket belt will be made up of forty buckets and four sets of powerful grab hooks. Each bucket will weigh 10 cwt., and, having a full capacity of 6 cubic ft., will hold 5 cubic ft. when inclined at an average dredging angle. The total weight of the ladder and buckets will be 40 tons. A steam winch will be provided with six barrels. The revolving screen will be 22 ft. long and 4 ft. 5 in. in diameter. The tables for catching the gold will be 18 ft. wide and 17 ft. long. They will have a fall of 1½ inches in the foot. The screen will be supplied with water by a 10-inch centrifugal pump. The elevator will be 35 ft. between centres. Power will be obtained from a 16 H.P. horizontal compound Marshall engine, which will derive its steam from a half Lancashire and half tubular boiler, with a fire-grate area of 20 sq. ft. The total weight of the pontoons, with all the machinery, will be 200 tons. The expense of building and launching such a dredge will be about £6,000. Theoretically it will be able to elevate and wash 133 cub. yds. of gravel per hour.

The majority of the dredges upon the Clutha are very much smaller than the one described above. The buckets upon the Molyneux Hydraulic Company dredge have only a full capacity of 4½ cubic ft., and those upon the "Moa" only hold 3 cubic ft., while other dimensions are about in proportion. The length of ladder depends upon the depth of ground which is to be worked. It is not advisable to have the ladder too long, since under these circumstances the buckets are always inclined at a low angle, and their working capacity is, in consequence, lowered.

The frames and plating of some of the pontoons are made of steel, but experience seems to have shown that timber is better adapted for this purpose.

One plant—the Sandhills dredge—engaged in exploiting the upper Shotover, deserves some mention, in so far as it is the only one in New Zealand which is driven by electrical power. The pontoons are constructed of steel. They are 80 ft. long, and the deck has a width of 20 ft. The buckets have a full capacity of 3½ cub. ft., and discharge at the rate of twelve per minute. This I found to be the rate of discharge adopted upon all dredges. The dynamos derive their power from a Pelton wheel driven by a stream of water, which has been imprisoned upon the mountain side at a height of 524 ft. above the power-house. There are two motors upon the dredge, one of which drives the chain of buckets and the winches, while the other drives the centrifugal pump. At the time of my inspection the dredge was working at a distance of 3 miles from the dynamos generating the current. The cost of the dredge was £2,600, and of the whole installation £7,000. A full account of the plant will be found in the paper which has been contributed to the Institute of Civil Engineers, London, by Mr. Robert Hay, M. Inst. C.E.*

Gold-saving Appliances.

Upon the older dredges, and upon a few of the modern ones, the buckets discharge their contents by way of a shoot into ordinary sluice-boxes. The average length of boxes is 30 feet, and the fall about 1 in 12. The gold is caught either upon cocoa-nut matting or plush. Sometimes the boxes are provided with ordinary ripples, but more often they are fitted with punched iron plates, as shown in the section through a sluice-box given below. The

a. Iron plate, ½-in. thick, with holes punched 1 in. apart.

b. Cocoa-nut matting.

large stones travel down upon the iron plates; the finer material and gold is washed by the water through the apertures, the latter being caught upon the matting. When the gold is very coarse tramway rails laid across the boxes have answered admirably as ripples. Mr. R. White has invented an arrangement of curved rail ripples, and applied the same to the Sandhills dredge under his charge. The curved rails ensure a more even lateral distribution of the material being sluiced.

With the introduction of the revolving screen a great advance was made in the process of treatment. The buckets discharge their contents into a shoot which leads into the upper end of the screen. Here a spray of water washes the fine material and gold through the perforations directly on to the tables arranged below, and the screenings are delivered by a shoot from the end of the screen into the buckets of the elevator, or, in the case of the older machines, directly into the river. The screens vary in length from 10 to 22 feet, and in diameter from 3 to 4 ft. 6 in. They make about ten revolutions per minute. The two screws upon the Molyneux Hydraulic Company's dredge have angle-iron worms inside, so that all the material passing into them, travels eight times the circumference of screen while under the influence of the water. In order to ensure a more even distribution of the fine sludge upon the tables, the perforations near the head of the screen are either of smaller size or are fewer in number than elsewhere. Water is supplied by means of a spray-pipe which enters the screen from behind. From 1,200 to 2,000 gallons of water per minute are required to ensure efficient washing.

* Pro. Inst. of Civ. Eng., vol. cxxi, Par. III.

The tables for catching the gold are upon most dredges arranged in three shelves, so that the centre of each table is equidistant below the screen. They have in the aggregate a width equal to the length of the screen, a length of from 10 to 14 ft., and a fall of 1½ to 1¾ in. to the foot. They are covered either with cocoanut-matting or plush, which is overlain with ¼-in. mesh rectangular wire-netting. The latter is found to answer admirably as ripples. The percentage of gold which is lost in treatment upon the best-equipped dredges is probably very small.

That the tables equipped as above are capable of saving extremely fine gold has been shown by measurements which have been made of the particles. "A sample of fine gold from the Electric Company's dredges, about 2 grains in weight, which had been sifted through a sieve of about 3,600 holes to the inch was again sifted through one of 4,900 holes, and the gold which passed through sorted under a powerful lens. One hundred of the smallest of these pieces were thus selected, and examined under a microscope. Measured with a micrometer, their dimensions in fractions of an inch varied between 0·009 x 0·006 and 0·003 x 0·002, the mean of twenty measurements being 0·0065 x 0·0042. The hundred particles were then carefully weighed, and found to have a mass of 0·097 of grain. The mean weight of the pieces was therefore 0·00097, or a little under one-thousandth of a grain."* I have measured a number of particles of gold comprised in a parcel from the Electric Company's dredges, and obtained results almost identical with those given above.

The Dredge at Work.

To keep a large dredge running continuously a crew of six men are employed. The ordinary wage being £3 per week. The manager or dredge-master is usually a skilled engineer in receipt of from £4 to £6 per week. He does not as a rule work upon shift, but lives somewhere close handy to the machine, so that he can be quickly upon the spot in the event of any breakdown occurring. It often is arranged so that one manager has several dredges under his control.

A good system of partly paying the men by results has been introduced by the owners of the Turakina dredge, Messrs. Park. The men receive 8s. 4d. per shift, and a bonus of 10s. per week in the event of the weekly yield of gold exceeding 20 oz., and 15s. if it exceeds 30 oz. This method seems to me to be an admirable one. A dredge hand requires to use his head more than his hands, and there is scope in the work for the display of a considerable amount of judgment. The chief desideratum is to keep the machine running as continuously as possible and the buckets fully charged.

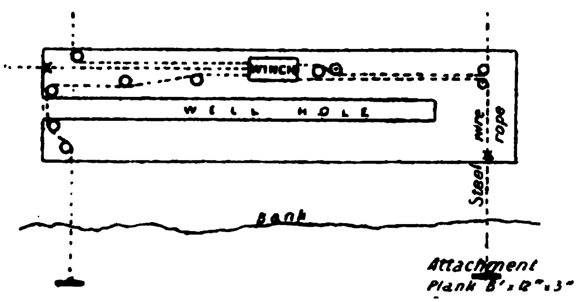
Two men are employed per shift. One attends to the winches, and the other does the stoking and looks after the engine. Before the introduction of the revolving screen the services of a third man were often required for the purpose of looking after the sluice-boxes. The winch-man is in charge of the shift; he keeps the dredge up to her work, and always keeps the up-coming buckets in view. Should a large boulder be lifted which is likely to damage the screen, he either breaks it when passing with a sledge hammer, or when it is not possible to do this stops the engine and levers it off.

* New Zealand Mining Journal, 1 Sept., 1897, p. 296.

Boulders up to a ton in weight are sometimes raised upon the grab-hooks. When after several attempts it has been found impossible to raise one of these obstacles, endeavour is made by excavating a hole with the buckets alongside to cause it to roll from its position.

The dredge is kept in position by means of five steel-wire mooring lines, two starboard lines, two port lines, and one head line. The shore ends of the lines are passed around stout planks and buried in the soil. Each dredge is provided with an anchor, to be used in case of emergency.

SKETCH ILLUSTRATING METHOD OF MOORING DREDGE.



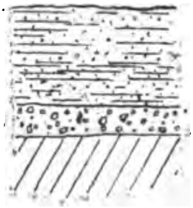
A dredge working into a flat cuts a passage for itself, breaking down the gravel in front and stacking it behind after it has been delivered of its associated gold. The greatest depth of ground (height of face) which it is possible to work is limited by the height of the elevator. In this connection it should be remembered that the elevated and loosely-packed gravel occupies a much greater bulk than when occurring *in situ*, consequently the depth of ground which it is possible for any dredge to work is always considerably below the height to which the same dredge is capable of elevating.

The Molyneux Hydraulic Company's dredge and other large machines can stack tailings up to a height of about 40 feet.

Dredge can be shifted over rapids or low falls.—This has been successfully accomplished upon the Shotover River by the manager of the Sandhills dredge, Mr. R. White, a system of locks being employed. The dredge is 95 feet long, and draws 2 ft. 6 in. of water. It is only when the river is in flood that there is sufficient water to float her; under ordinary conditions she has to cut a channel for herself. The greatest fall that has been negotiated is 15 feet in a length of 2 chains. Some of the rougher projecting rocks are first of all removed by a few charges of dynamite. The dredge is then hauled up as closely as possible to the rushing water, and a rude stone weir is built immediately behind it. This weir by impounding the water enables a forward movement to be made when a fresh wall is built, and the process is repeated until the top of the fall is reached. Four stone walls were required in the case of the highest fall, and the cost of the whole operation was trifling.

Problems for the Future.

Many low-lying auriferous flats are seen when examined in section to be made up as shown below.



Under these circumstances a difficulty will be experienced in keeping the dredge afloat, for the fine material, by passing through the apertures of the screen, will escape the elevator and be deposited around and underneath the pontoon. When the dredge attacks the flat from a swift-flowing river like the Clutha it may be possible by a judicious disposal of the tailings to divert a portion of the water so that there is always sufficient current astern to carry off the silt. However, the obstacle would be fatal to operations carried out in shallow still water in the absence of special precautions. An easy solution of the problem could be found in pumping the whole of the sluice-water with the fine material in suspension over the tailings heap; but this would necessitate a most extravagant expenditure of power. At least 1,600 gallons of water per minute are consumed in the washing-plant of an ordinary dredge; so, in the event of the tailings being stacked at an elevation of 20 feet, over 10 h.p. will be absorbed in lifting the water alone, where 16 h.p. is sufficient for all purpose upon the largest dredge. Engineers have for some time past been endeavouring to devise a method of overcoming the difficulty, and speak hopefully of being finally able to do so.

In one instance the pontoon was provided with a settling tank and small bucket elevator, which lifted the deposited silt and discharged it into the main elevator, so that it was carried up and stacked with the screenings. This arrangement does not seem to have answered very well. The elevator working in the sandy sludge was soon destroyed; and, moreover, no method of adjustment was provided, so the contrivance could not be used to work ground containing a constantly varying quantity of fine material.

Another obstacle which has caused dredge-owners to look askance at considerable stretches of river, which are otherwise well adapted for their purpose, is a hard, rough bottom.

A small quantity of very fine gold is scattered throughout the Clutha drifts; but the greater portion—at least 80 per cent.—is found in the crevices of the bedrock or in the layers of gravel immediately adjacent. Such being the case, it is evident that success depends in a great measure upon whether the upper layer of rock is soft enough to permit of its being scooped up by the buckets. Under other conditions not only is the gold not obtained from the crevices, but the motion of the buckets is impeded and likely to be suddenly checked by projecting rocks.

The clayey sandstones which occur upon the river at Cromwell and elsewhere form an ideal bottom to work upon; but a difficulty is often experienced in those localities where the gravels rest upon the older slates and schists. It is necessary, however, that one should be very cautious in expressing an opinion as to whether a river-bottom is adapted for dredging or otherwise. Indeed, when the drift deposits extend to a great depth this question can only be satisfactorily answered after prospecting operations have been carried out. In several places upon the Clutha the same schists, which appear hard and unyielding upon the bank, have been found to be soft and pliable beneath the river.

In working upon flats or in shallow, sluggish rivers—and the majority of our New South Wales rivers are of this character—it may be possible to dredge close down to the bottom, and finally clean the same with the aid of divers. For the purpose of raising the small quantity of gravel which the buckets were unable to reach, and for cleaning out the crevices, sand-pumps controlled by the divers might, perhaps, be used with advantage. The rapid current would render it dangerous to employ divers upon the Clutha.

In this connection it is important to note that the gold in many river drifts is not confined to the bottom, but is more or less evenly distributed through a considerable thickness of gravel, or a portion of it may have been deposited upon a false bottom at some distance above the bedrock. While prospecting the auriferous gravels upon the Shoalhaven River, in 1893, I obtained, in many instances, a higher yield of gold from a false bottom than from the bedrock below; and several beds of gravel were tested in which no concentration of the precious metal upon the bottom could be detected. It is obvious that, under such circumstances, dredging might be profitably carried on, notwithstanding the presence of a hard rough bottom.

Another impediment to the industry is to be found in the occurrence of decaying logs or tree stumps. The Clutha is practically free from these obstacles; but they have given considerable trouble to the dredges working the Buller River, upon the west coast of New Zealand.

In the event of the auriferous ground being clayey there will be a tendency for it to adhere to the buckets. This might, perhaps, be provided for by causing a spray of water to play into them when they are discharging their contents. A much more serious difficulty will arise, however, in the event of the clay being present in sufficient quantity to render puddling necessary as a preliminary operation to the ordinary treatment. The process, besides absorbing a large quantity of water, is long and tedious; and, even should it be possible to successfully carry it out upon a dredge, its introduction would of necessity considerably lower the output.

Working Expenses of Dredge.

The weekly cost of running a large dredge in New Zealand is as follows:—

	£	s.	d.
Fuel—16 tons of lignite at 12s.	9	12	0
Labour—5 men at £3 and 1 at £5	20	0	0
Repairs, office expenses, &c.	20	0	0
	49	12	0

A large dredge working favourable ground is capable of elevating and washing at least 90 cubic yards of gravel per hour. For instance, the buckets upon the Molyneux Hydraulic Company's dredge have a capacity of 4½ cubic feet, say 3½ cubic feet when inclined at an average dredging angle, and twelve bucket-loads are delivered per minute, so there should be 93 cubic yards delivered per hour. Suppose such a dredge to work twenty-two hours out of every twenty-four, and six days per week, then it will treat 12,276 cubic yards per week. Now, as the gravel in the buckets will be loosely packed and occupy a larger space than when in situ, an allowance must be made, and I propose to reduce the above amount by one quarter, this will leave it at 9,207. Suppose the gravel to contain gold at the rate of a grain (in round numbers a value of 2d.) per cubic yard, then the value of the precious metal won per week would be £76. Deduct 10 per cent. for loss in treatment (the loss under ordinary circumstances is nothing like as great as this), and the amount becomes £69. Again deduct the working expenses of the dredge £50, and £19 will remain. Hence it is possible by means of a large dredge to work ground containing only a grain of gold per yard at a profit. It must always be remembered, however, that the quantity of material which a dredge is capable of raising within a certain time varies considerably with the nature of the ground.

As an instance of the profits obtained in dredging low-grade ground, I will quote the published returns of the Jutland Flat (Waipori) Gold-mining Company for two years:—

	1896.	1897.
Dredging wages time for period	6,171	5,846 hours.
Actual lifting during same period	5,678	5,518 „
Estimated quantity lifted	402,919	398,608 cub. yds.
Gold obtained	1,135	1,177 oz.
Average yield of ground	1·35	1·41 grs. per yd.
Paid in dividends	£1,125	£1,875

During 1896, £707 was expended in litigation. If this amount is added to the dividends paid, the actual profit for this year, after deducting all working expenses, will stand at £1,832.

Gold Dredging in Montana, U.S.A.

I am indebted to an article contributed to the *Engineering and Mining Journal* by Mr. E. B. Braden, for all the information contained under this heading.*

Two varieties of machine are being employed—floating dredges, which have been constructed after the fashion of those working upon the Clutha River, and "Traction" dredges, which travel upon wheels, and are designed to work upon dry land. "River (floating) dredges are successfully operating on Grasshopper Creek in Beaver Head County; Traction or land mining machines are working satisfactorily at Washington Gulch, Deer Lodge County, and in Alder Gulch, near Virginia City."

The raising of auriferous gravel by means of suction pumps was tried first of all, and resulted, as was the case in New Zealand, in failure.

The first attempt to use a bucket dredge was made three years ago, but it was not until the dredge had been rebuilt twice that satisfactory results were obtained.

"The 'A. E. Graeter' was launched for the Bannock Dredging Company last June, and a plant for the Bon Accord Mines is almost completed. It is 102 feet in length, 32 feet wide, and draws 3 feet of water. With the

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* Gold Dredging in Montana: Eugene B. Braden, *Engineering and Mining Journal*, Nov 20, 1897, p. 605

engines, boilers, and other machinery carried, the total weight is nearly 700,000 lb. Steam is generated by two tubular steel boilers, of the locomotive type, with grates arranged to use pine and fir wood for fuel. There are thirty-five buckets, with a capacity of 5 cubic feet each, and excavations can be carried to a depth of 38 feet."

The dredge only seems to essentially differ from the larger New Zealand machines in regard to the arrangements for shifting and moving. "It is equipped at the rear end with two spud timbers 42 in. × 18 in. × 50 ft. in size, and weighing 11,000 lb. each. These are each fitted with a pointed steel wearing shoe at the lower end, and with the necessary gearing for raising and lowering. These spuds are for moving the dredge forward or backward, being alternately raised by means of hoisting cylinders of 24 tons capacity and dropped after the dredge has been swung by the engineer in the pilot-house through the cables passed around the front corners of the boat to a lateral anchorage. The boat is thus walked ahead. While excavating, one of these spuds rests in the gravel at the bottom, and forms a pivot, around which the boat is swung as the gravel is taken up. By means of the suspensory cables carrying the bucket-ladder, this ladder is lowered about 6 inches with each swing of the dredge around the anchored spud. Thus with the drag of the bucket a segment of gravel 6 inches deep and 8 feet wide is excavated. This lowering of the ladder continues until bedrock is reached. The bedrock, if yielding, is torn loose and brought up until barren of values."

The percentage of gold extracted is stated at 98 per cent. The cost of working gravel when steam is employed has been found to be 9 cents (4½ pence) per cubic yard. This includes labour, supplies, running repairs, and superintendence. On the "F. L. Graves," where electricity is employed for power, this cost has been 4½ cents (2¼ pence) per cubic yard.

"The traction dredge or land-mining machine at Washington Gulch has been designed to work in ground that is unusually flat, and where but little water is obtainable. It is owned and operated by W. M. Johnston & Co., of Chicago, who also designed the plant. The builders were the Marion Steam Shovel Company, and the Gates Ironworks. It works dry gravel, and where the machine cannot sufficiently clean the bedrock, this work is done by hand labour. The entire plant is supported on four bogie trucks which move on double tracks 12 ft. apart, laid on the bedrock. No jack-arms, side braces or spuds are used. Steam is supplied by one 50 h.-p. boiler to a set of dredging engines of the same capacity. These perform the excavations, handle the car, run the washer and trommel, and move the plant forward when required. The part of the machinery by which the excavating is accomplished is similar in design to that used for such purposes on steam shovels. The boom is 40 ft. long, and carries a dipper or shovel of 1¼ cubic yard capacity, and handles 70 cub. yds. per hour. The water supply to this plant for all purposes is 20 miner's inches.

In this gulch the bedrock lies some 16 ft. below the surface. Above this is the auriferous gravel on which is a considerable overburden of barren material. This latter is first stripped off and disposed of at the side without washing. The pay gravel is then taken up by the shovel and dumped into a car at the other side of the plant which runs on an incline. One end of this incline rests on a shoe set in solid ground on the bank of the cut, and the other terminates on the roof of the dredge. The car, when filled, is handed up by a cable, operated by the engines and pumped into a hopper on top of the plant. The gravel passes into a washer and trommel, when complete disintegration is effected, and the coarse gravel and rocks passed out at the rear end of the plant. The finer gravel, sand, gold, and water pass through the perforations of the trommel into a sluice box originating immediately below. This sluice extends some distance behind the plant, being carried by suspensory chains for regulating the grade. The saving of gold accomplished in this system is 97 per cent. and 98 per cent. The machine has operated ten hours every day since May 18th, with the exception of Sundays and one day while awaiting material with which to make repairs. Eight and sometimes nine men have been employed, three of whom do the work of cleaning the bedrock by hand. About 1⅓ cords of fir wood are consumed per shift of ten hours.

This dredge is the first of this design to be constructed. Others are being built which will embody improvements that have been suggested by the work done here."

Before concluding, I desire to convey my thanks to the Honourable H. J. Cadman, Minister for Mines, Mr. H. J. H. Elliott, Under Secretary for Mines, and numerous engineers and other residents of Otago, for the great kindness shown to me, and for the assistance they rendered me in obtaining the information set out in this paper.

DESCRIPTION OF PLATES.

Plate I.

The Chicago Dredge.

A tailings elevator is here seen at work, and the variation between the height of the loosely stacked tailings and the face of ground being attacked is apparent.

Designed and built by Mr. K. S. Sparrow, engineer, Dunedin.

From photograph by W. Esquilant & Co., Dunedin.

Plate II.

The Moa Dredge.

It has been one of the most successful dredges upon the Clutha. The picture shows it working in the Clutha River a short distance below Alexandra.

Originally constructed according to the design of Mr. E. Roberts, and recently altered by Messrs. Cutter Brothers. From photograph by W. Esquilant & Co., Dunedin.

Plate III.

The Molyneux Hydraulic Co.'s Dredge.

This is probably the largest machine working at the present time upon the Clutha. The great length of the elevator (60 feet) enables the tailings to be stacked at any height not exceeding 35 feet. These are two revolving screens.

A nozzle has been erected upon the bow of the pontoon, so that when a steep bank is being attacked the ground can be "hydrauliced" in advance, and the risk of the ladder and buckets being buried beneath heavy falls thereby minimised. It is doubtful whether the advantages accruing from the use of the nozzle compensates for the large amount of power which it consumes.

At the time of my inspection the dredge was working into a face of gravel 25 feet high.

Designed by Mr. E. Roberts, consulting engineer, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

Plate IV.

The Earnscleugh No. 1 Dredge.

This dredge is represented leaving the Clutha River, and commencing to attack a river flat.

Designed by Mr. E. Roberts, consulting engineer, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

Plate V.

The Manorburn Dredge.

Here a dredge is seen exploiting an auriferous flat away from the river altogether. It is cutting a channel for itself, breaking down the bank of gravel in front, and stacking it, when delivered of its gold, behind.

The ladder, with the system of gear pulleys used for raising and lowering, are well shown.

Designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

Plate VI.

The Enterprise.

An historic interest is attached to this dredge, in so far as it was the first one to be supplied with an elevator for the tailings. The elevator is shown at work.

Designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. Reproduced from a photograph by W. Esquilant & Co., Dunedin.

Plate VII.

The Perseverance Dredge.

A "current wheeler" is here shown at work in the centre of the Clutha River, a short distance above Alexandria.

These machines being dependent upon the current for power can only work where the stream flows rapidly.

From photograph by W. Esquilant & Co., Dunedin.

Plate VIII.

A portion of the Manukerikia River, with alluvial flats which are about to be exploited by dredges.

From photograph by W. Esquilant & Co.

Plate IX.

A flat upon the Clutha, showing Hyde and party's No. 1 and No. 2 dredges and the "Perseverance" at work.

Plate X.

Electric Company's No. 2 Dredge.

The galvanised iron house not having been erected, the general arrangement of the machinery upon the pontoon can be seen.

The machine is remarkable on account of its long ladder. It can dredge to depths of 60 feet.

Two pairs of grab-hooks, which enable boulders up to a ton weight to be raised, will be seen upon the bucket belt.

From photograph given to me by Messrs. McGeorge, of Cromwell.

Plate XI.

Plan and sections of the A. E. Graeter dredge, which is working at Bannack, Montana, U.S.A. It differs from any of those upon the New Zealand rivers in being provided with two pivots, by means of which it can be anchored or moored short distances backwards or forwards.

The plate has been reproduced from that which accompanies the article on Gold-dredging in Montana, by Eugene B. Braden, "Engineering and Mining Journal," 20th November, 1897, p. 605.

Plate XII.

Plan and section of Matau Dredge, showin general arrangement of machinery.

This dredge has been designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. When completed it will be launched upon the Clutha River to work ground about 3 miles above Alexandria.

Reproduced from a photograph by W. Esquilant & Co., and supplied to me by Mr. W. H. Cutten.

Plate XIII.

The Kawarau dredge, designed by Mr. J. C. McGeorge, consulting engineer, Dunedin, to work very deep ground. It has the longest ladder of any machine in New Zealand. When launched, it was supplied with an elevator 25 feet long, and the revolving screen was lengthened 4 feet.

Drawings of an elevator, with chain of buckets detached, have been added. The plate has been prepared by Mr. O. Trickett, draughtsman to the survey, from the tracing which was supplied to me by Mr. A. McGeorge, engineer, Cromwell.

Reference to Plan and Section.

A. Gantry, with gear-pulleys for raising and lowering ladder.
B. Ladder.
C. Winches.
D. Anchor winch.
E. Engine.
F. Boiler:
G. Tumbler, driving bucket belt.
H. Revolving screen.
J. Screen pipe.
K. Screenings shoot.
L. Gold-saving tables.
M. Pump.
N. Starboard mooring lines.
O. Port mooring lines.
P. Head mooring line.

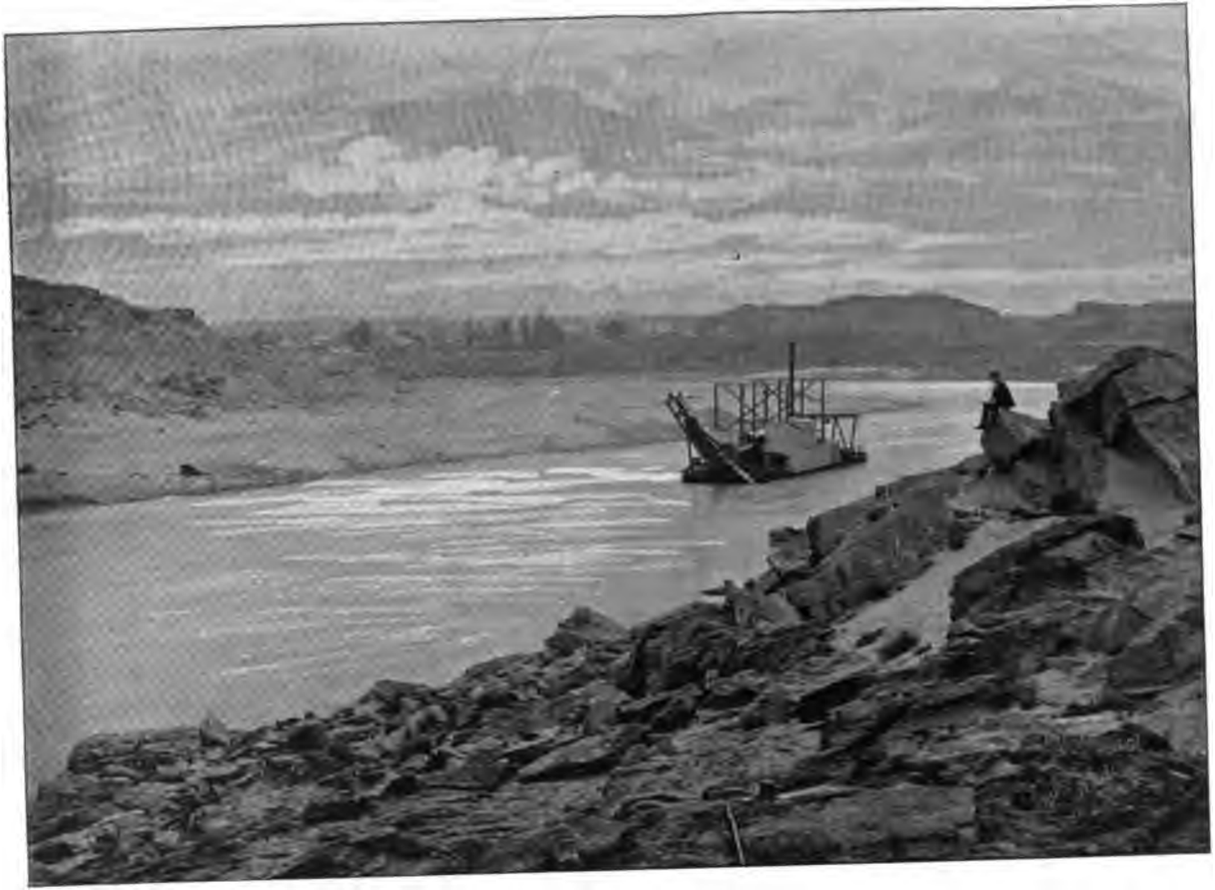
[Plates, &c.]

Sydney : William Applegate Gullick, Government Printer.—1898.

Plate I.

THE CHICAGO DREDGE.

Plate II.



THE MOA DREDGE.

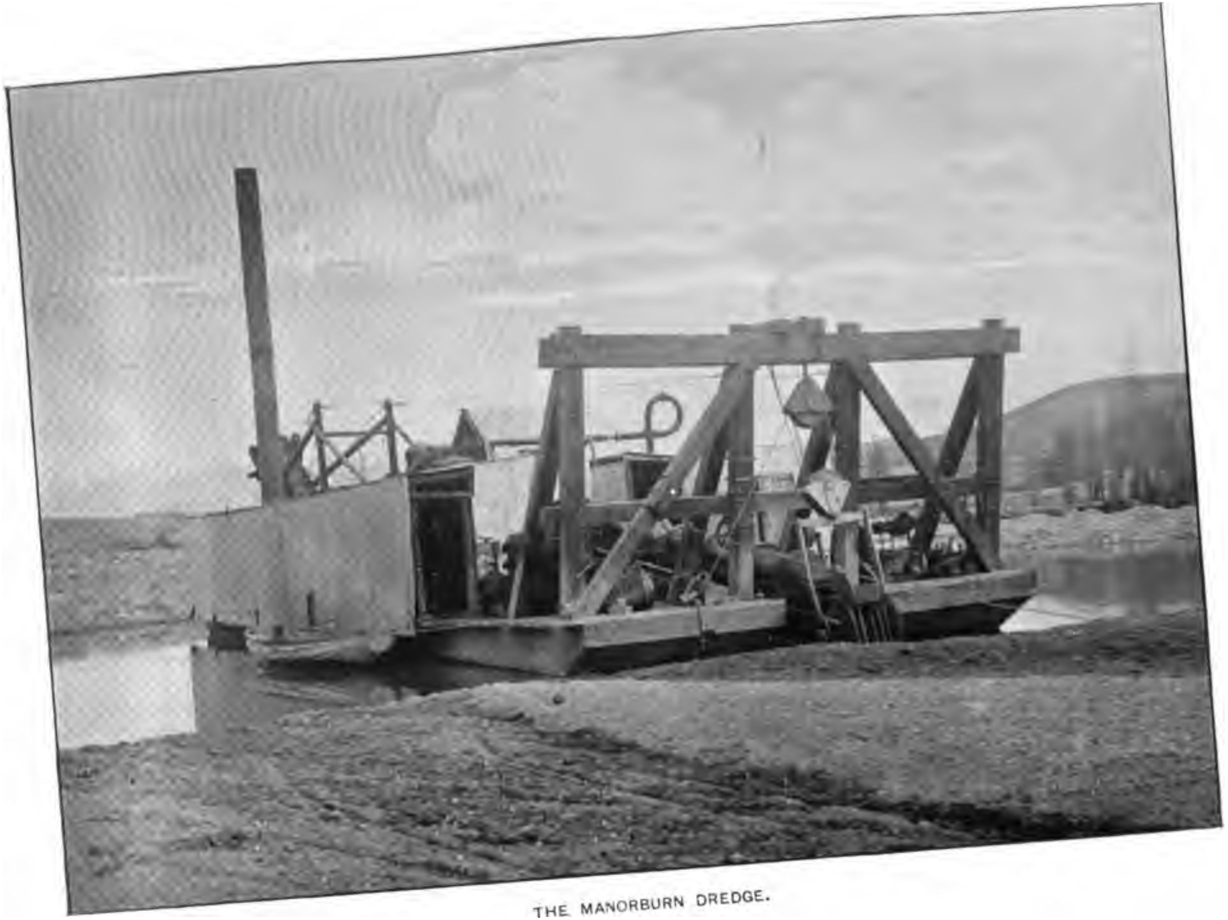
Plate III.

THE MOLYNEUX HYDRAULIC CO.'S DREDGE.

PLATE IV.

THE EARNSCLEUGH No. 1 DREDGE.

PLATE V.



THE MANORBURN DREDGE.

PLATE VI.

THE ENTERPRISE DREDGE.

PLATE VII.

THE PERSEVERANCE DREDGE.

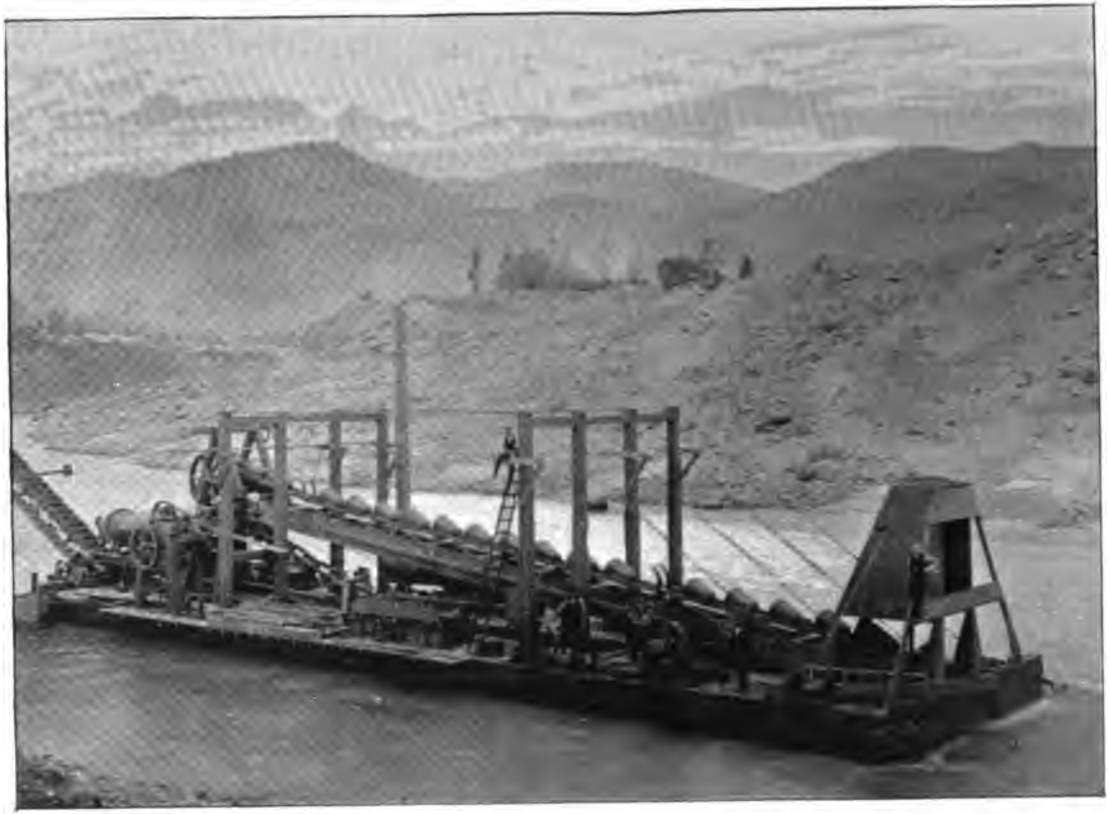
Plate VIII.

MANUKERIKIA RIVER.

Plate IX.

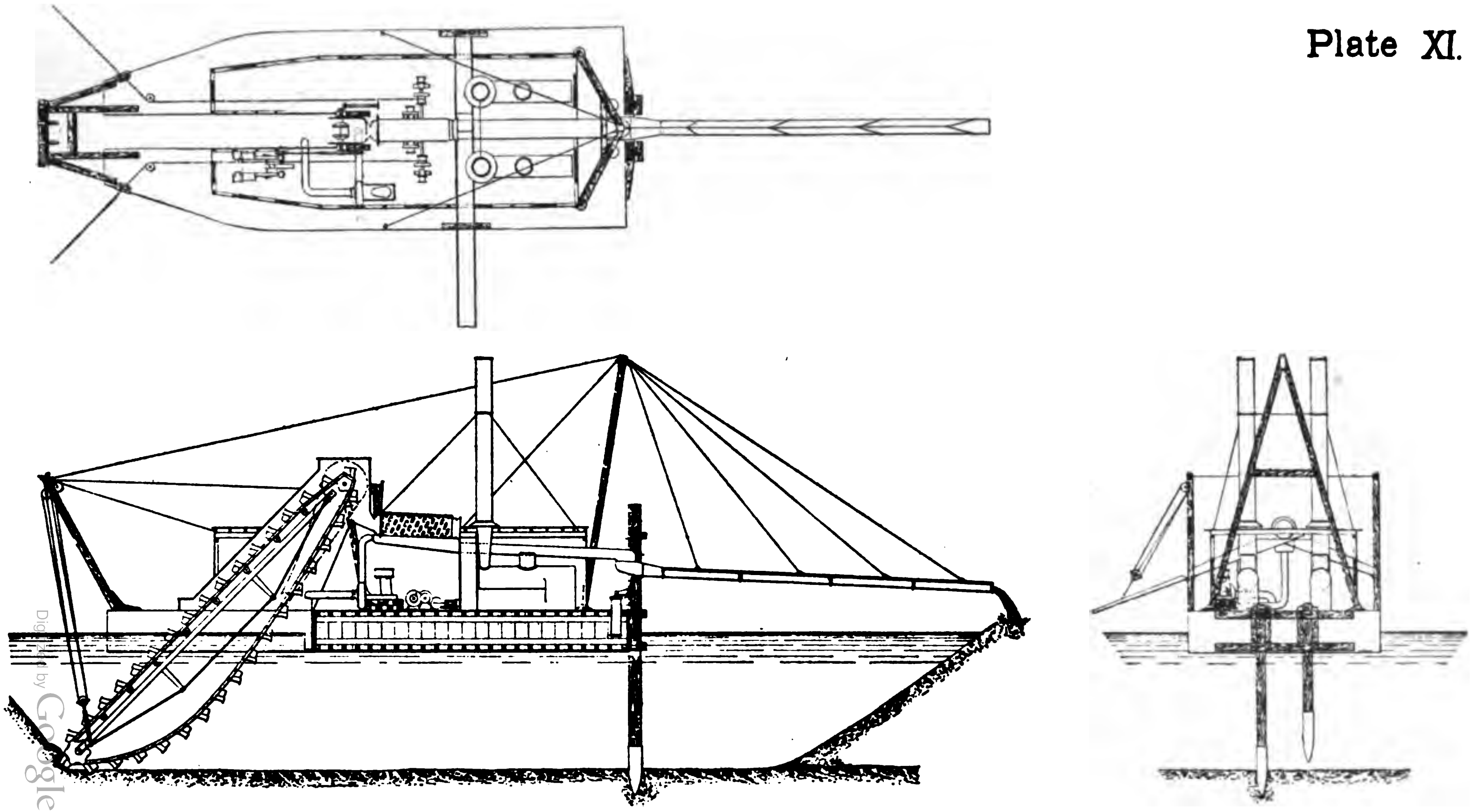
A FLAT UPON THE CLUTHA.

PLATE X.



ELECTRIC CO.'S No 2 DREDGE.

Plate XI.



Plan and Sections of "A.E. Graeter" Dredge.

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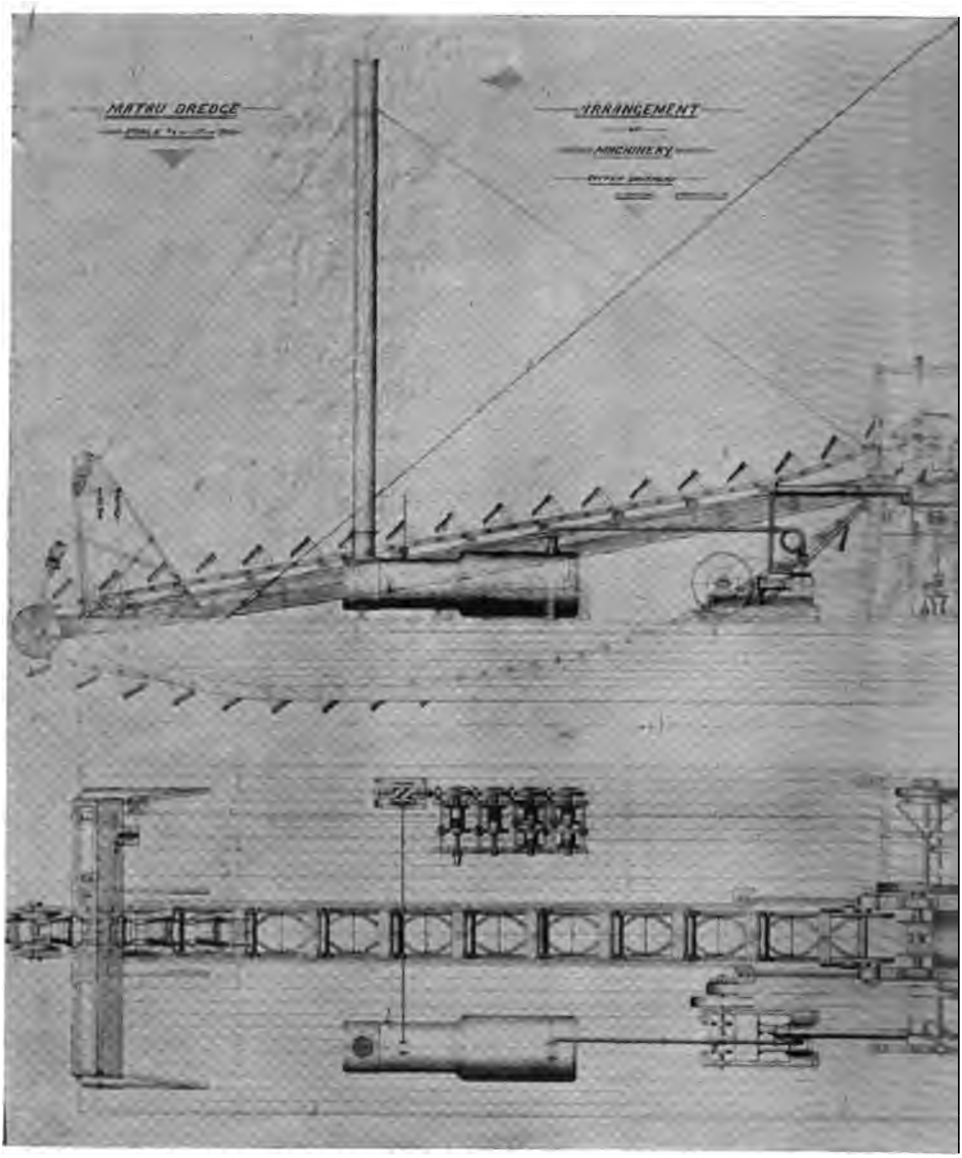
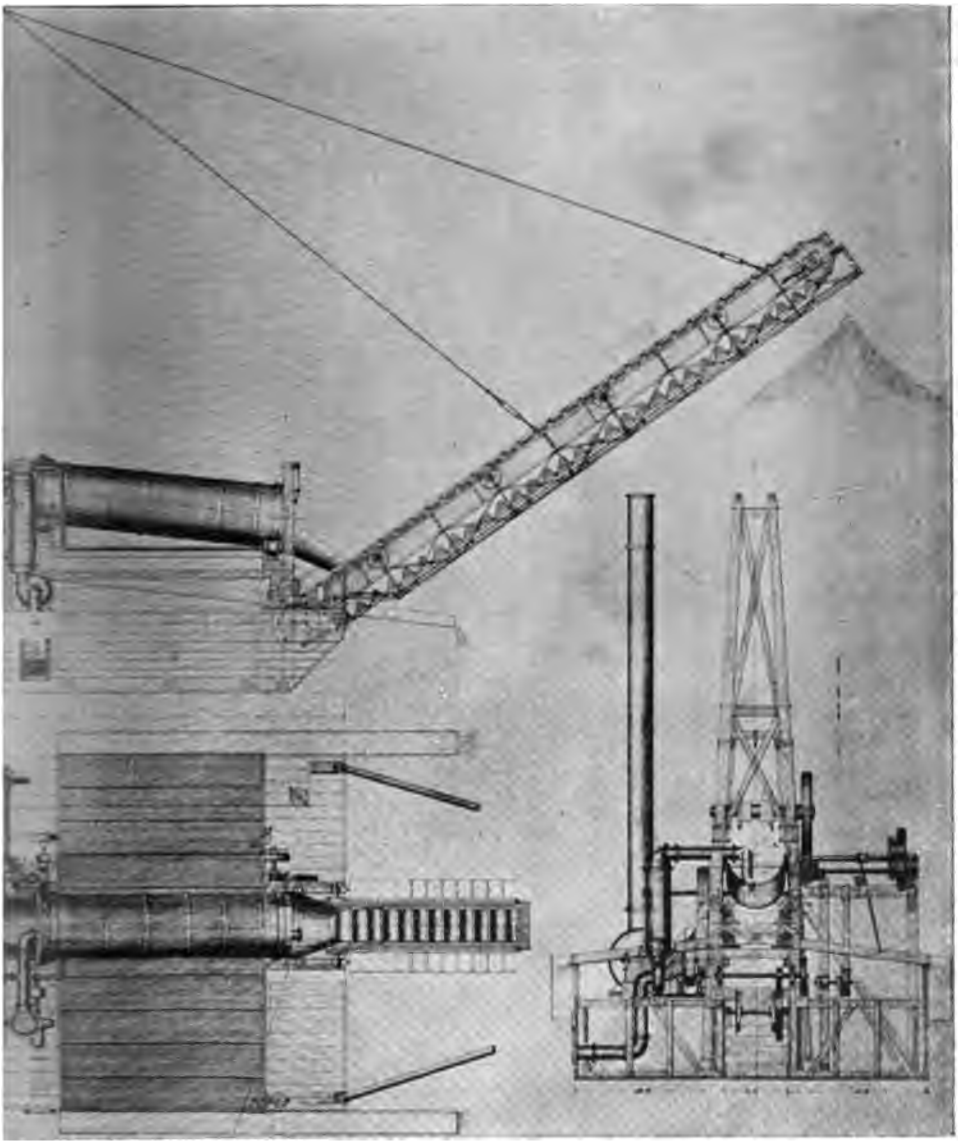


MATAU

E XII.



DREDGE.

NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 4.

NOTES

ON THE

OCCURRENCE OF BISMUTH ORES

IN

NEW SOUTH WALES.

BY

J. A. WATT, M.A., B.Sc.,

GEOLOGICAL SURVEYOR.

1898.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1898.

28943 A [6d.]

Geological Survey of New South Wales,
Department of Mines and Agriculture,
Sydney, 7th September, 1898.

Sir,

I have the honor to submit for publication Report No. 4 of the Mineral Resources Series, entitled "Notes on the Occurrence of Bismuth Ores in New South Wales," by Mr. J. A. Watt, M.A., B.Sc., Geological Surveyor.

There have been in the past numerous inquiries at the Department of Mines in regard to the production of the various metals and ores of New South Wales, the different localities in which they are found, their uses, and particulars as to their mode of occurrence. Much time was consumed in answering these inquiries, more especially as it was necessary, in most cases, to refer to a number of Annual Reports in order to collect the information required.

With a view of making information in regard to the mineral wealth of the Colony more easily accessible to the public, and at the same time bringing it up to date, the idea was conceived of issuing a series of short monographs under the general title of "Mineral Resources," each of which should treat of a separate metal or ore.

The success which has attended the publication of the three first monographs on "Chromic Iron Ore," "Tungsten Ores," and "Gold Dredging," respectively, is proof that the mining community recognise the advantages of being able to obtain complete information in regard to any metal in a concise and handy form.

It is hoped that the present number, on Bismuth Ores, will be found as useful as those which have preceded it.

Other monographs are in course of preparation, and will be issued as soon as possible.

I have the honor to be, Sir,
Your obedient Servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for
Mines and Agriculture.

Notes on the Occurrence of Bismuth Ores in New South Wales.

CONTENTS.

Note.—No claim is laid to originality as regards the contents of this paper. In writing the introductory portion liberal use has been made of text-books and scientific papers dealing with the subject; and in the remainder there is little more than may already be found in the Annual Reports of this Department. The information that was scattered through so many publications has been brought together, and thus made available for the use of those interested in this branch of the Mining Industry.

I.—Introduction.

Properties of Bismuth.—Bismuth is a comparatively rare metal of a silver-white colour, in which a distinctly reddish tinge is noticeable. This metal, which has a specific gravity of 9·83, melts at a temperature of 270° C. (507° F.).

On passing from the fused to the solid state, it increases considerably in volume; on this property, coupled with its low fusibility, many of the uses to which bismuth has been applied depend. Metallic bismuth is so brittle that it can be readily pulverised.

As to its chemical properties, we find that nitric acid, and a mixture of that with hydrochloric acid dissolve bismuth readily. From solutions so formed the bismuth is easily precipitated by the addition of a large quantity of water, or, better still, by pouring the solution into a large volume of water. From the nitric acid solution the bismuth is precipitated, by the method just described, as a basic nitrate, a white insoluble compound, which has been largely used as a cosmetic, and is somewhat extensively employed in medicine. From a solution obtained by the use of the mixed acids a white precipitate of the oxychloride is formed.

Chief Ores of Bismuth.—Bismuth occurs in nature principally as native or metallic bismuth; but with this are associated, especially in the upper portions of lodes where a process of oxidation has been going on, other compounds, such as the oxide and carbonate, which occasionally occur in sufficient quantities to be economically important.

The sulphide (Bismuthinite, Bi_2S_3) is also not an uncommon ore. It usually occurs massive, with a foliated or fibrous structure, and has a metallic lustre and lead-grey colour. The carbonate (Bismutite, $Bi_2O_3.CO_2.H_2O$) varies in colour from white to straw-yellow and yellowish green. The only other compound that it is necessary to mention here is the telluride (Tetradymite), a mineral of a steel-grey colour and metallic lustre.

The ores are almost without exception associated with other metallic minerals which are the primary object of the mining operations, the bismuth being treated as an accessory constituent of the ores.

A

Tests for Bismuth in Ores.—The ordinary bismuth ores are not difficult to identify, owing to their low fusing points. If the presence of bismuth is suspected in any mineral, a small piece of it should be placed on charcoal and the blowpipe flame applied to it. Should the mineral fuse easily, and the charcoal in the vicinity of the fused mass become coated with an incrustation which is orange-yellow while hot, and lemon-yellow when cold; and, moreover, if a metallic globule remains on the charcoal, which is brittle and does not mark paper, it may be safely concluded that a bismuth mineral is present.

As a corroborative test, a portion of the mineral might be powdered and heated with nitric acid, and a small portion of the solution poured into a large volume of water, when a white precipitate, or with small quantities a turbidity, announces the presence of bismuth.

A good test is the heating of a little of the mineral, previously powdered, with sulphur and a little iodide of potassium, when, if bismuth be present, a beautiful bright-red incrustation will be formed on the charcoal.

Antimony ores, which resemble those of bismuth in their easy fusibility, may be readily distinguished from the latter in that they give a white incrustation when heated on charcoal, and are insoluble in nitric acid.

Uses.—The uses that have been made of bismuth and its compounds are few, and, consequently, there is but a limited demand for the metal.

One of the most important applications to which the metal has been applied, is in the production of fusible alloys, whose valuable properties depend on their low fusibility and the phenomenon of expansion during solidification. Bismuth alone fuses at a very low temperature, viz., about 270° C., but some of its alloys fuse at much lower temperatures, much below that of boiling water.

The most important of these alloys are:—

	Bismuth.	Lead.	Tin.	Cadmium.	Melting-point.
Newton's Metal.. ...	8 parts	5 parts	3 parts	......	94·5° C.
Rose's ,, ...	5 ,,	3 ,,	2 ,,	......	91·6° C.
Wood's ,, ...	15 ,,	8 ,,	4 ,,	3 parts	68° C.
Fusible ,, ...	2 ,,	1 ,,	1 ,,	......	93·7° C.

Alloys consisting of lead, tin, and bismuth, mixed in such proportions that the mixture fuses at some particular temperature above 100° C., have been employed for safety plugs for boilers, but it is said that they have been found untrustworthy owing to the separation of the more fusible components of the alloy, when the plugs have been subjected to continuous heating near its actual melting-point. Alloys have also been used in automatic sprinklers placed in the ceilings of buildings as a safeguard against fires. The apertures of the sprinklers are closed by plugs of the alloy, which melt when unduly heated, and thus allow the water to flow from the sprinklers.

Fusible alloys have been used in stereotyping, in obtaining copies of woodcuts, &c.

The basic nitrate of bismuth is used in medicine, and as a cosmetic; and this compound, as well as the oxide, is employed in the manufacture of a highly refractive glass, and to give a colourless iridescent glaze to the surface of porcelain. Other compounds are also somewhat extensively used as medicines.

Occurrence of Bismuth Ores in Nature.—Although bismuth ores are known to occur in many countries, the deposits of economic value are comparatively few. The chief European mines which furnish bismuth ores are those of Schneeberg, Altenberg, Annaberg, and Johanngeorgenstadt, in Saxony, which were, indeed, at one time the sole producers of these ores. In these mines the bismuth occurs chiefly in the native state; but the sulphide and the carbonate are frequently present. At Schneeberg the bismuth ores occur in cobaltiferous veins. In the Austrian Erzgebirge, Bohemia, ores of bismuth are found in the argentiferous veins near Joachimsthal, and in tin-bearing deposits. At Rezhanya bismuth occurs as a telluride, associated with the tellurides of the precious metals. Austria, between the years 1869 and 1895, produced 9,638 metric tons of bismuth ore, nearly the whole of which went to the Saxon Works for treatment.

Prussia has produced small quantities of bismuth ore.

Important deposits of bismuth ore occur at Tasna and Chorolque, in Bolivia, which contain also tin and the noble metals. Bismuth occurs in these places in the native state, and as ochre and carbonate—the ores containing from 20 to 30 per cent. of bismuth.

The ores of Chorolque are found in porphyry, while those of Tasna are in slates. These mines are said to have enough ore in sight to supply the whole world for several years to come; but only sufficient is sent to the market to meet the small demand.

At Meymac, in France, bismuth ores were at one time obtained. They occurred there in a vein in granite, which contained wolfram and arsenical pyrites near the surface, and bismuth ores at greater depths.

Bismuth ores are known to occur in nearly all the Australian colonies; but they have been obtained in quantity only in Queensland and New South Wales. In Queensland, bismuth deposits exist at Mount Biggenden, Mount Shamrock, on the Percy River, and at Eukalunda. Between 1891 and 1895, inclusive, 452 tons of ore were exported from Queensland.

The great bulk of the bismuth of commerce comes from the Saxon Works at Schneeberg; a little also from Freiberg and Altenberg. Bismuth is also produced in England, where Australian and Bolivian ores are treated.

II.—Bismuth Ores in New South Wales.

Coming now to the more immediate object of this paper, an alphabetical list is now given of the localities in New South Wales from which bismuth ores have been recorded. Against the name of each place is given the information contained in the official records of the character of the ores, and their mode of occurrence at that place. The information here furnished is rather meagre. This arises from the fact that in the case of only two of the deposits have geological examinations been made; while the great bulk of our knowledge consists of the results of assays of samples sent to the Departmental Laboratory. This accounts for the absence of knowledge as to the exact localities from which many of the samples have been derived.

The late Mr. C. S. Wilkinson made an examination of the Kingsgate deposits in 1883, and in 1889 the Mount Mitchell deposits, near Glencoe, were reported on by Mr. W. Anderson.

The limited demand for the metal, and the manipulation of the market by a "Ring," are factors that have greatly retarded the development of our bismuth deposits.

Note.—The following abbreviations are made use of:—

D.L.—Departmental Laboratory attached to the Geological Branch.

A.R.—Annual Report of the Department of Mines and Agriculture; when the year is given, it means the Report for that year, which is published during the following year.

Bi.—Bismuth.

Au.—Gold.

Ag.—Silver.

The results of assays are always given in percentage of metallic bismuth, and in ounces, pennyweights, and grains of gold and silver per ton.

Adelong.—Picked specimens of quartz containing iron pyrites, mispickel or arsenical pyrites, and metallic bismuth from a reef in the vicinity of Adelong were assayed in the D.L. in 1879, and found to contain Bi. 5·6 per cent. Mr. Slee, Chief Inspector of Mines, has mentioned the association of iron, copper, and arsenical pyrites, as well as zinc blende, and galena in the richest quartz of the Adelong Gold-field.

Bombala, 20 miles west of.—In A.R. 1894, p. 56, an assay is given of a sample stated to have come from a locality 20 miles west of Bombala. As there is no other record of bismuth ore from this locality, while similar ore occurs at Whipstick, which is about an equal distance east of Bombala, it is very probable the sample came from there. It yielded Bi. 14·83 per cent., Au. 11 dwts. 20 grs., Ag. 7 dwts. 14 grs.

Broken Hill.—See Mount Gipps.

Captain's Flat.—See Norongo.

Cobar.—Nine samples of copper ore from the Great Cobar Copper Mine, assayed in 1878, were all found to contain bismuth. The amount of this metal present in the ores varied from 0·21 per cent. to 2·58 per cent., the average of the nine samples being 1·53 per cent. The presence of this bismuth caused some difficulty in the refining operations. An analysis of the refined copper made in 1878 showed it to contain 0·419 per cent. Bi.

Deepwater.—See Pye's Creek.

Dundee.—A sample of quartz, wolfram, and carbonate of bismuth from this locality was assayed in 1897, and gave Bi. 1·42 per cent.

Emmaville.—Several small pieces of native bismuth encrusted with oxidized products were received at the Curator's office in May of this year. These were said to have been obtained at a place 3 miles from Carpet-snake Creek, in the Emmaville district.

Ewingar.—See Solferino.

Germanton.—Two samples from this place were assayed in 1890; one consisting of quartz with sulphide and carbonate of bismuth yielded Bi. 6·49 per cent., and the other, consisting of quartz with felspar, mica, oxides of tin and molybdenum, and molybdenite, yielded Bi. 0·99 per cent.

Glen Creek.—Two samples purporting to come from Glen Creek, near Emmaville, were assayed in 1897; one, containing carbonate and sulphide of bismuth, gave Bi. 2·77 per cent., the other, consisting of arsenical pyrites with clay, gave Bi. 0·96 per cent.

Water-worn fragments of bismuth have been recorded (See Prof. David's Memoir on the Vegetable Creek Tin Mining Field, page 163) from near Taylor's veins, on the Glen Creek.

Glen Innes.—One of the earliest references to the occurrence of bismuth ores in this Colony is that by Mr. Martin, Warden for the district, in A.R. 1877, page 109, where he says: "On this eastern watershed (of the New England Table-land) bismuth has been found in many widely separated places, and in one instance traced to the lode." The Kingsgate deposits are in all probability referred to here. See Kingsgate.

Glencoe.—See Mount Mitchell.

Gulf.—Mr. Slee, Chief Inspector of Mines, reported in 1880 having seen metallic bismuth near the Gulf, Vegetable Creek.

Gumble.—In 1886 a crushed sample of mineral, which was said to have come from Gumble, near Molong, gave on assay Bi. 11·76 per cent. A lode, from which the above sample probably came, was found on private land between Gumble and Delaney and Kelly's Mine. It was 2 feet in width, and a shaft 30 feet in depth was sunk on it. Samples from this lode were said to have yielded from 3 per cent. to 18 per cent. Bi., and 4 oz. silver per ton.

Highland Home, Parish of.—Lumps of native bismuth weighing a quarter of a pound, have been picked up near Burn's Reef, in Portion 3, Parish of Highland Home, County Gough. (See Prof. David's Memoir previously referred to.)

Hillgrove.—Three samples, said to have come from Hillgrove, were submitted for assay in 1891. Two consisted of quartz with a little carbonate of bismuth. One of them gave Bi. 12·11 per cent., Au. 4 dwts. 8 grs., and Ag. 3 oz. 18 dwts. 16 grs., and the other Bi. 3·37 per cent., Au. trace, and Ag. 1 oz. 12 dwts. 16 grs.

The third sample, which was a quartz-sand, which had been previously washed, contained a little carbonate of bismuth and cassiterite, and gave on assay Bi. 24·42 per cent., Au. 10 dwts. 21 grs., and Ag. 11 oz. 6 dwts. 11 grs.

Another sample from near Hillgrove, consisting of felspathic lode-stuff with galena, assayed in 1893, gave Bi. 4·74 per cent., Au. trace, and Ag. 6 oz. 17 dwts. 3 grs.

Hogue's Creek.—In his report* on the bismuth lodes near Glen Innes, Mr. Wilkinson mentions that "about 12 miles north from Glen Innes, and about 1 mile east from the Tenterfield road, several bismuth and tin-bearing quartz-veins have been discovered. These occur in a different manner from those at Kingsgate. They form irregular veins and masses of quartz traversing a fine-grained micaceous felsitic rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length of about 100 yards and a width of 15 yards, is traversed by a network of quartz-veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore (cassiterite), molybdenite, arsenical pyrites, and wolfram. In another place, about 100 yards from that last named, a mass of hard crystalline quartz, in size at the surface about 40 feet by 20 feet, has been opened for a few feet in depth. It contains bismuth and tin ores, together with a large quantity of wolfram.

"Besides this, two other small veins of quartz, yielding bismuth and tin ores, crop out close by. I do not consider that the vein-stuff here can be profitably worked for tin on account of the occurrence in it of so much wolfram; but for bismuth mining the prospects are encouraging, and the reefs should be further tested."

Kingsgate.—In this locality the most important of the known bismuth deposits of the Colony occur, and these have furnished the greater portion of the ore produced in the Colony.

Developmental work seems to have commenced at the mines on the Kingsgate Run in 1879, during which year a bulk sample of 8 cwt. of ore was raised and sent to Sydney. In A.R. 1880, page 143, Mr. Warden Martin gives the following particulars of the bismuth lodes at Kingsgate:—

"Although bismuth has been long known to exist in the district, mining for the ore is an industry only six months old, and was commenced at Kingsgate, 18 miles easterly of Glen Innes. Originally the land at this spot was taken up for tin, but indications showing that ores of bismuth were abundant, led to that metal being alone mined for. The lodes in which the ore is found are 6 to 8 feet wide, with an east to west bearing, and probably a north and south connection. There are many of them exposed on their bearing for

* Report on Auriferous Antimony Lodes at Hillgrove and Bismuth Lodes near Glen Innes. By C. S. Wilkinson. Ann. Rept. Dept. Mines N. S. Wales for 1883, pp. 154-155.

a length of about 10 chains. The matrix is quartz. The country is rough and wild and of granitic formation, backed by basalt-covered table-lands about 3 miles distant from the mine.

"The Manager of the Kingsgate Mining Co., in his report for the half-year ending 11th December, 1880, states that—

4½ tons of ore	...	containing	50 per cent. Bi.
30 „ of rock ore	...	„	5 to 10 per cent. Bi.
30 „ of slimes	...	„	5 per cent. Bi.

and 2,000 tons quartz, by assay value £4 per ton, were won from the lode during the six months from an open cutting. Samples of native bismuth from this mine shown me weighed from 1 to 2 lbs. Four and a half tons of ore from this mine were forwarded for sale to London. . . ."

In the early part of 1883 these bismuth deposits, which are situated at Kingsgate, near Yarrow Creek, and about 16 miles east of Glen Innes, were geologically examined by Mr. C. S. Wilkinson, whose report* I append almost in full.

"The formations are granite and altered slate, forming rough, broken country, with valleys about 500 feet deep. The line of junction of the two formations is well defined, and the bismuth lodes occur in the granite in proximity to this line or within about 400 yards from it. The mode of occurrence of these so-called 'lodes,' is very remarkable; they are pipe-veins or oval masses of quartz of variable thickness, descending in a more or less vertical direction in the granite, as though well-like caverns of very irregular diameter had been formed in the granite and filled with quartz and metallic minerals. Thus in one lode in the Kingsgate Company's property two masses of quartz (which the manager, Mr. W. Yates, informed me were 30 feet apart at the surface), on being followed down, united and formed one large pipe-vein about 27 feet in diameter, and of irregular shape, from portions of it protruding here and there into the granite. Nests or bunches of bismuth ore (native bismuth, sulphide, carbonate, and oxide of bismuth) were obtained about these protruding portions as well as through the mass of quartz, and in order to take out the vein-stone, a large excavation about 60 feet by 40 feet has been made. The vein has only been sunk upon to a depth of 50 feet. The quartz is of a coarsely crystalline nature, and contains, in patches, a considerable quantity of molybdenite. The metallic bismuth and sulphide occur in the solid quartz, but the carbonate and oxide lie chiefly in the joint fissures in the quartz. Sometimes masses of native bismuth are found between crystals of quartz in the vein, and when removed the impress of the quartz crystals is well shown. Some splendid specimens, from 4 to 6 lbs. weight, from this mine were presented by the Company to the Mining and Geological Museum. . . . The largest mass of native bismuth found here weighed nearly 30 lbs.

"Other similar veins, but smaller, have been proved, though only for a few feet in depth; one contains much arsenical pyrites and hexagonal plates of molybdenite. An average sample of these sulphides gave on assay—

Metallic bismuth, 2·6 per cent.
Fine gold, at the rate of 8 dwts. per ton.
Silver, at the rate of 3 oz. 5 dwts. per ton.

"On portion 25, about half a mile north-west from here, another large pipe-vein is being opened. Near the surface it consists of a very ferruginous mass of quartz, about 13 feet by 9 feet, containing bismuth, arsenical pyrites, wolfram,

*Ann. Rept. Dept. Mines and Agric. for 1882, pp. 27-29; and for 1883, pp. 154-155.

and molybdenite. The screened vein-stuff is said to yield about 50 lbs. of bismuth ore per ton, which will probably be equal to about 1 per cent. of ore from the whole vein-stuff.

"A sample of the ore consisting of mixed particles of native bismuth, carbonate, sulphide, and oxide, yielded on assay—

Metallic bismuth, 69·3 per cent.
Fine gold, at the rate of 4 oz. 1¾ dwts. per ton.
Fine silver, at the rate of 57 oz. 3 dwts. per ton.

"The result of the assay of the ironstone from this vein was 0·6 per cent. of bismuth, and no gold; and the arsenical pyrites gave only a trace of gold and bismuth, with silver at the rate of 12 oz. 5 dwts. per ton. The gold, therefore, appears to be almost entirely contained in the bismuth ore, probably in the metallic portion of it.

"Several veins of a similar nature have been opened on the Glen Innes Company's property, which adjoins that of the Kingsgate Company. The Company is now sinking upon a vein which is said to have been 1 foot wide at the surface; but when I saw it at a depth of 40 feet (the lowest level then reached), it was 4 feet wide. This vein is in granite, and close to the boundary of the slate formation. The vein-stuff is thickly studded with large brilliant steel-grey plates of molybdenite, some of them being more than 3 inches in diameter. Nodules of native bismuth, larger than walnuts, with carbonate, sulphide, and oxide of bismuth, occur through the vein, and in greater quantity in places where the molybdenite becomes abundant. Another vein, situated about 100 yards from this, contains, besides bismuth ore and molybdenite, some arsenical pyrites, which latter yielded on assay 9·2 per cent. of metallic bismuth, fine silver at the rate of 92 oz. 14 dwts. per ton, and no gold.

"About 3 miles east from the Yarrow Creek head station, and about the same distance in a south-easterly direction from Kingsgate, is the Comstock Bismuth Company's Mine. No work was being done here at the time of our visit; but we saw three pipe-veins of hard white crystalline quartz which had been opened for only a few feet from the surface. The shafts were partly filled with water, so that the exact size of the veins could not be measured; but the largest of them appeared to be about 6 feet by 15 feet near the surface. A sample of bismuth ore collected from the heaps gave on assay—

Metallic bismuth, 35·6 per cent.
Fine gold, at the rate of 2 oz. 9 dwts. per ton.
Fine silver, at the rate of 9 oz. 16 dwts. per ton.

"Thus, again, we see that the bismuth ore contains gold. These veins are also in granite, and distant about 200 yards from the slate formation. It is a somewhat remarkable feature that all the bismuth veins (eighteen) as yet found occur in the granite, within a short distance from the slate; and it is probable that on further examination of the country along the line of junction of the two formations other veins will be discovered."

Molong, 25 miles from.—In 1889 a sample, said to have come from this locality, and consisting of quartz and carbonate of bismuth, gave Bi. 13·05 per cent.

Moor Creek.—See Tamworth.

Mount Dromedary.—A small vein, from a few inches to over a foot in thickness, has for many years been worked on Mount Dromedary. It traverses the granite forming that mountain in a nearly east and west direction. A sample from this vein yielded on assay Bi. 1·66 per cent., Au. 2 oz. 15 dwts. 12 grs., and Ag. 10 oz. 15 dwts. 19 grs.

Mount Emily, near.—In 1895 a sample of weathered granite from near Mount Emily and to the south of Quambi, containing bismuth ores, yielded Bi. 6·39 per cent., Au. 4 dwts. 8 grs., and Ag. 2 oz. 1 dwt. 9 grs.

Mount Gipps.—An assay was made in 1884 of a brown mineral with cavities filled with carbonate of bismuth, which was said to have come from Mount Gipps, 13 miles north of Broken Hill, in the county of Yancowinna, with the following result:—Bi. 14·55 per cent., Au. nil, Ag. 4 oz. 18 dwts., and traces of copper and cobalt.

Mount Mitchell.—Three samples of ore from this locality were assayed in 1888; two of them, consisting of quartz and carbonate of bismuth, contained respectively Bi. 5·91 per cent. and 1·44 per cent. The third was a concentrated sample and consisted of quartz, carrying native, oxide, and carbonate of bismuth. This yielded on assay Bi. 62·0 per cent., Au. 4 oz. 11 dwts. 10 grs., and Ag. 1 oz. 1 dwt. 16 grs.

These bismuth deposits of Mount Mitchell, near Glencoe, were geologically examined in 1889 by Mr. W. Anderson, whose report* is given almost in full.

"The position of these bismuth-bearing veins is in the north-west corner of the parish of Coventry, county of Clarke, and is about a mile to the south-east of Mount Mitchell. The bismuth ores occur distributed in small irregular patches through a series of quartz-veins averaging from half an inch up to 4 inches in thickness. The quartz is clear and translucent and towards the centre of some of the veins is crystalline, the pyramidal apices of the crystals from opposite sides of the veins interlocking in the centre. The contained bismuth ore is in the form of oxide, sulphide, and carbonate of bismuth, which in many cases are found to cover a central nucleus of metallic bismuth. The veins traverse a ternary granite, whose general texture and mineral constituents vary very much. Their strike is south-west and north-east, and they pass downwards in a nearly vertical direction, with a slight inclination to each other, as if they would unite at a lower depth. Their outcrop can be traced for a considerable distance along the surface, and small quantities of bismuth can be washed from the soil in the immediate neighbourhood of the outcrop. The veins contain a fair percentage of free gold. Little or no work has yet been done in opening up or proving the extent of the bismuth-bearing veins. A couple of holes have been sunk, averaging about 10 feet deep. The mode of occurrence of the bismuth ores here differs slightly from that at the Kingsgate mines, in that at the latter place they occur in pipe-veins near the junction of the granite with the slate, while here they are found in quartz-veins traversing the mass of the granite. Of two assays made of the quartz, one returned 5 per cent. of metallic bismuth, with traces of gold, and the other showed traces of metallic bismuth. . . . It will no doubt be found, on proving these veins, that they are more or less lenticular in shape, thickening and thinning out, and running together in a very irregular manner, although probably on the same vertical line. They do not present, so far as one can judge from their present development, the same prospects of such large quantities of bismuth ore being obtained as in the case of the pipe-veins of Kingsgate."

Nanima.—Auriferous bismuth ores occur in quartz-veins at Nanima, 3 miles east of Murrumbateman in the Yass district. There are several reefs in that locality, some of them 3 or 4 feet wide, which run in a north and south direction and underlay to the east. A sample collected by Mr. E. C. Whittell gave on assay Bi. 6·37 per cent., and Au. 1 oz. 7 dwts.

* Ann. Rept. Dept. Mines and Agric. for 1889, p. 231.

Nimitybelle.—Bismuth ores were found near Nimitybelle, in the Southern district, in 1888, in which year a sample consisting of quartz and sulphide of bismuth was assayed, and found to contain Bi. 3·67 per cent. An area of 79 acres was taken up with the object of mining for this metal. Since 1888 several samples of the ore, which consist of sulphide of bismuth, with quartz as a veinstone, have been assayed in the D.L., and have given returns varying from 2·71 per cent. to 8·81 per cent. Bi.

Norongo.—Telluride of bismuth was found at Norongo, 8 miles south of Captain's Flat, in 1888, and samples were forwarded to this Department for assay. Two samples, consisting of carbonate of bismuth and tetradymite, were assayed; one was found to contain 19·26 per cent. of metallic bismuth, and the other 27·88 per cent. of bismuth and 10·42 per cent. of tellurium. A third sample consisted of clay, with carbonate of bismuth and tetradymite, and contained 16·9 per cent. of bismuth, a trace of gold, 2 oz. 3 dwts. 13 grs. of silver per ton, and 7·04 per cent. of tellurium. Another sample, consisting of carbonate and sulphide of bismuth, gave 60·2 per cent. of bismuth.

The chemical composition of the telluric-bismuth ores from this locality has been described in some detail by Mr. Mingaye,* who gives the following particulars of the occurrence of the ores:—"The mineral was discovered at Norongo, about 8 miles south of Captain's Flat, in a gossan lode about 16 feet wide, through which runs the vein containing the mineral, the latter being 6 inches in width, and occurring at a depth of about 2 feet from the surface."

The physical character of these ores were described by Prof. David,† who identified the following minerals:—tetradymite, montanite, and telluric-bismuthic ochre. The two latter surround nuclei of tetradymite, and evidently owe their origin to the alteration of the tetradymite.

Nymagee.—In 1895 it was reported that very promising indications of the existence of payable deposits of bismuth were met with in the Nymagee district. No steps have, I believe, been taken to open up these deposits.

Oban.—Two samples from this locality were assayed in 1889; one, consisting of native bismuth, carbonate and oxide of bismuth, gave Bi. 75·60 per cent. and Au. 2 oz. 7 dwts. 21 grs., and the other, a friable earthy carbonate of bismuth, yielded Bi. 10·04 per cent. A third sample was assayed in 1891; this consisted of quartz and felspathic gangue, with molybdenite, and yielded Bi. 1·45 per cent., Au. 4 dwts. 8 grs., and Ag. 2 dwts. 4 grs. These samples may possibly have come from the Mount Mitchell deposits.

Orange.—A sample of bismuth ore, said to have come from the vicinity of Orange, was assayed in 1882, and gave Bi. 5·4 per cent. and Ag. 4 oz. 2 dwts.

Pye's Creek.—In one of the veins on Pye's Creek, in the parish of Annandale, county Clive, bismuth is reported to have been discovered in some quantity. (See Prof. David's Memoir previously referred to.) A 40-acre block next to Hamilton & Co.'s lease was taken up for the purpose of mining for this metal. In 1885 three samples of bismuth, bearing material from Pye's Creek, were assayed with the following results:—

(1) Ferruginous quartz and metallic bismuth from 40-acre block adjoining Hamilton and party's lease gave Bi. 66·8 per cent., and Ag. 33 oz. 8½ dwts.

(2) Ferruginous quartz with metallic bismuth and carbonate of copper from the same locality yielded Bi. 3·9 per cent., and Ag. 200 oz. 18 dwts.

(3) Ferruginous sand and galena and a little carbonate of copper from the same place gave Bi. 13·3 per cent., and Ag. 166 oz. 12 dwts.

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* Records Geol. Surv. N. S. Wales, Vol. I, pt. 1 pp. 26–28.
† Records Geol. Surv. N. S. Wales, Vol. I, pt. 1, pp. 29–30.

Silent Grove.—The Chief Inspector of Mines reported (A.R. 1880, page 220) the existence of a lode 8 inches in thickness at Silent Grove, in the Vegetable Creek district, on the property belonging to Mr. Alexander Stuart, of Sydney. The bismuth lode in this locality occurs under the same conditions as those at Kingsgate, viz., in granite close to its junction with altered slates.

Prof. David, in his Memoir on the Vegetable Creek Tin-mining Field, page 163, mentions that bismuth "has been found native, and as carbonate and sulphide associated with tin-stone and quartz, in portion 15, parish of Silent Grove, county Clive. The total width of the vein is about 1 foot, and its strike 15 degrees south of east and north of west, with a northerly dip. The bismuth is distributed through the quartz chiefly in acicular crystals, and lies next to the foot-wall; the thickness of the bismuth-bearing part of the vein is 4 inches."

Slippery Creek.—Telluride of bismuth was found by Mr. E. C. Whittell, Field Assistant, at Mitchell and Party's claim, near Slippery Creek, in the Oberon district. Mr. Card,* who identified the mineral, writes as follows:—"It occurs along with free gold in small grains and flakes in the quartz, and is associated with greenish and yellowish alteration products. The telluride is probably auriferous."

Solferino.—A sample of brown iron ore from this district near Ewingar was assayed in 1890, and found to contain carbonate of bismuth yielding Bi. 69·95 per cent., and Ag. 2 oz. 5 dwts. 17 grs. Another from the same place, consisting of brown iron ore with a little oxide of bismuth, gave Bi. 0·63 per cent.

Sunny Corner.—Small quantities of bismuth have been found in the ore of the Sunny Corner Mine. An analysis is quoted by Mr. C. S. Wilkinson in his report on that mine (A.R. 1886, page 140), in which 0·88 per cent. Bi. was found in the ore.

Tamworth.—Telluride of bismuth has been recorded from Moor Creek and Sawpit Gully.

Tent Hill.—A sample of decomposed micaceous rock from this locality assayed in 1897 gave Bi. 3·46 per cent.

Tenterfield.—Two samples of bismuth-bearing material were sent in 1879 to the D.L. for assay; one, a yellow ochreous mass, consisting of carbonate and oxide of bismuth associated with quartz and molybdic oxide, stated to have come from Tenterfield, was found to contain Bi. 43·29 per cent., and 6·6 per cent. of molybdenite. The other, said to have been derived from a reef 4 feet wide, occurring near Tenterfield, consisted of metallic bismuth, carbonate of bismuth, and molybdic sulphide and oxide in a matrix of quartz; this yielded on assay Bi. 60·09 per cent., Au. 1 oz. 4 dwts. 10 grs., and Ag. 8 dwts. 10 grs.

In 1889 a sample of quartz with oxide of bismuth gave on assay Bi. 2·72 per cent.; and in the following year a sample of compact felsite with oxide of tin, magnetic iron ore, and a little carbonate of bismuth, yielded Bi. 1·50 per cent.

Tingha.—Samples of bismuth ore have been forwarded from time to time from Tingha for examination. In 1878 waterworn nodules of carbonate and oxide of bismuth, white to dark-brown in colour, were assayed by Mr. Dixon, and found to contain Bi. 60·43 per cent. Rolled fragments of the same, associated with talc and ferric oxide, contained Bi. 62·75 per cent.

Land was taken up in 1885 in the remote south-west portion of the Tingha Division, for the purpose of mining for bismuth ore.

* Records Geol. Surv. N.S. Wales, 1897, V., Pt. 2, p. 66, Mineralogical Notes by G. W. Card, A.R.S.M.

.vo samples of material, stated to have come from Tingha, were assayed 887; one, consisting of quartzite with metallic bismuth, contained Bi. per cent.; and the other, an artificially concentrated sample of native uth and its oxide, gave Bi. 76·62 per cent. In the following year two samples from the same locality, consisting of ferruginous quartz, with ve, oxide, and carbonate of bismuth, were assayed; one gave Bi. 5·36 per t., and Au. 13 dwts. 6 grs.; and the other Bi. 1·06 per cent., but no gold.

Uralla.—Telluride of bismuth has been recorded by Mr. Card, from ntucky Run, near Uralla, where it occurs in association with free gold a white quartz.

Whipstick.—Rich argentiferous bismuth ores have been obtained in the eat Jingera Silver Mine, which is situated 10 miles west of Pambula and miles east of Wyndham. Mr. Warden Maunsell wrote in 1891 as llows:—"The lodes here consist of soft granular felspar matrix, impregted with blotches of bismuth, molybdenum, and chloride of silver. They e capped with granitic rock, containing a large percentage of manganese, hite mica, and garnets. The country rock consists of quartz, felspar, white ica coarsely crystalline. . . . The Great Jingera Proprietary Silvermining Company hold eight leases for an area of 203 acres. It is opening ap the lode in several places. From an outcrop on mineral lease No. 4 it has despatched 4 tons of ore, averaging 1,170 oz. of silver to the ton, and from 3 to 10 per cent. of bismuth. The mine is situated on the summit of the North Jingera Range, about 1,500 feet above sea-level."

In 1892 the Great Jingera Silver-mining Company sent away to Europe 31 tons of argentiferous bismuth ore, which gave a return of 3½ tons of bismuth, 12 oz. of gold, and 6,107 oz. of silver, of a total value of £2,343.

In the A.R., 1897, page 42, it is pointed out that 1,430 tons of ore were raised during that year, of which 146 tons were sold and exported The estimated value of the bismuth sold was £3,100, and that of the silver associated with the bismuth, £264.

Wyndham.—See Whipstick.

Yarrow Creek.—See Kingsgate.

Production of Bismuth Ore in New South Wales between 1879 *and* 1897.

Year.	Yield.	Value.	Year.	Yield.	Value.
1879	0·40 tons	......	1889	42·50 tons	£11,349
1880	4·5 "	......	1890	2·10 "	306
1881	12·5 "	£2,728	1891	0·4 "	500
1882	2·7 "	162	1892	14·0 "	1,080
1883	3·7 "	650	1893	......	......
1884	14·37 "	2,770	1894	......	......
1885	14·0 "	3,700	1895	......	......
1886	20·9 "	3,870	1896	41·0 "	490
1887	36·55 "	6,695	1897	3·1 "	800
1888	18·07 "	3,911			

Sydney: William Applegate Gullick, Government Printer.—1898.

NEW SOUTH WALES

DEPARTMENT OF MINES AND AGRICULTURE

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.
No. 5.

REPORT

ON THE

WYALONG GOLD-FIELD.

BY

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Geological Survey Branch,
Department of Mines and Agriculture,

Sir, 21 January, 1899.

I have the honor to transmit for publication a report (accompanied by a geological map) on the Wyalong Gold-field, by Mr. J. A. Watt, Geological Surveyor.

The Wyalong Gold-field was discovered in 1893, and it has since been developed so vigorously that it is, at the present time, the most productive field in the Colony. The characteristic lenticular lodes in which the gold was first found near the surface, and which occurred in decomposed granite, have been proved to extend downwards into the undecomposed rock, and to preserve their general character, as well as their productiveness, to considerable depths. The permanence of the field, therefore, appears to be assured.

With regard to the question of alluvial deposits, it is, I think, premature to assert that such deposits do not exist in the neighbourhood, though it is a fact that they have not yet been discovered. The difficulties in the way of finding alluvial leads in such flat country as that surrounding Wyalong are very great, seeing that the surface presents no features that would serve as guides to prospectors. The same difficulties exist in portions of Western Australia, where alluvial gold was not discovered for a considerable time after the lodes had been proved, and where, I feel convinced, many more alluvial leads will yet be found.

There can be no doubt that very extensive denudation of the Wyalong District took place in Tertiary times; the present configuration of the surface supplies proof of this, and further evidence is afforded by the existence of a Tertiary basin, at least 900 feet thick, which exists near the junction of the Murray and Darling Rivers. The average annual rainfall of Wyalong is 13·63 inches, but there is reason for supposing that in Tertiary times the rainfall in Australia was very much greater than it is at the present day. The altitude of Wyalong is nearly 800 feet above sea-level, and I think therefore that there must have been, during the Tertiary period, well-defined channels through which the drainage of this elevated district found its way to the sea, or to the basin or lake just alluded to, the bottom of which is at least 1,300 feet below the present level of Wyalong. In such drainage channels the gold derived from the denudation of the auriferous reefs must have been concentrated, and I venture to think, therefore, that alluvial leads will yet be discovered in this district.

I have the honor to be, Sir,

Your obedient Servant,

EDWARD F. PITTMAN,

Government Geologist.

The Under Secretary for Mines.

CONTENTS.

Report on the Wyalong Gold-field.

By J. ALEX. WATT, Geological Surveyor.

4th January, 1899.

PART I.

1. The Discovery of Gold at Wyalong.

The Wyalong Gold-field has already proved itself so rich and extensive that one naturally feels surprised that it remained so long undiscovered. An examination of the Gold-field, however, at once furnishes us with adequate reasons to account for this delay in its discovery. Among the most important we may mention (*a*) the absence of alluvial-gold deposits; (*b*) the level nature of the ground, and its almost universal covering of red soil; (*c*) the absence of natural supplies of surface water; (*d*) the sparsely-settled condition of the surrounding country; and (*e*) the extremely fine condition of the gold.

The influence of (*a*) will be understood when we remember that alluvial deposits, sometimes extremely shallow, have been found on nearly all the large gold-fields; that these were first found and worked, and that it was only later that the gold was traced to the reefs. The result of (*b*) is that there are very few outcrops of reefs, as these are nearly all concealed by the superficial deposits.

The absence of natural supplies of surface water, and the sparsely-settled condition of this part of the Colony, must have proved almost insuperable obstacles to the prospector.

The influence of (*e*) is evident, for in much of the stone, even where it is rich and the gold is in the free state, it is in such a fine state of division that it can scarcely be detected with the naked eye.

The foregoing facts, as well as explaining the delay in the discovery of this gold-field, show also the amount of credit that is due to the Neeld family for their discovery.

It was not to prospect for gold, however, that Mr. Neeld left Victoria and came over to this Colony; but having made several unsuccessful attempts to obtain a sufficiently large area for selection in the neighbouring colony, he made up his mind to take up land for a similar purpose in this Colony.

With this end in view, one of the sons, then at Hiawatha, near Wyalong, was commissioned to look out for land suitable for settlement in that neighbourhood. As a result, a somewhat small area was obtained at Wyalong, and the family came over and settled down on it. The whole of this selection was afterwards resumed, for as mining developments advanced it was found that a large part of the auriferous area was contained within the boundaries of the selection.

Mr. Neeld, who has had considerable experience on the Bendigo, Ballarat, and other Victorian gold-fields, seems to have been impressed by the auriferous indications immediately on his arrival on the 2nd August, 1893. The ironstone nodules and loose fragments of quartz had attracted his attention. No time was lost in commencing prospecting operations, for on the morning after his arrival he tried several dishes of the surface material, but did not succeed in finding gold. Still he persevered, and one morning, about a month after his arrival, the first gold was found. This was in a loose piece of quartz. Several other pieces were found, taken to the camp, crushed, and washed, when a nice trail of fine gold was found in the dish.

The site of this first discovery of gold at Wyalong was on what was afterwards known as the Pioneer Claim. (*See* map.) A fortnight elapsed from the date of this discovery before systematic prospecting operations were started.

As there were practically no outcrops, the method consisted in examining loose fragments of quartz and washing dishes of the surface rubble. In this way the gold was traced gradually up the slight inclines, until no further prospects could be obtained. Near this spot narrow trenches were dug through the soil and rubble into the decomposed granite, until the reef was located.

While Mr. Neeld was prospecting the first discovery, one of his sons found gold-bearing stones just outside the selection, and about ten chains to the east of the former site. The reef from which these stones were derived was soon located. This site was afterwards known as the Dead Rabbit Claim, and later still as the Easter Gift. Later developments proved these two discoveries to be on the same line of reef.

In estimating the difficulties surrounding the prospecting of this part of the gold-field, it must be noted that these early discoveries were made in the midst of thick mallee scrub.

The third discovery was made by Mr. Harry Neeld, who picked up auriferous stone just within the mallee scrub, and on the site now known as Harry's Find. This is on Klink's line of reef, and adjoins Klink's Claim, which has paid large dividends. Harry's Find has remained in the possession of the Neeld family, and has yielded a large amount of payable stone. The next discovery was made on what is now known as the Red Flag Claim. Gold was also found near the site now occupied by the Currajong Mine, but no prospecting was done there. Up to this time shafts varying from a few feet up to fourteen feet deep had been sunk on the various finds.

The most important discovery was made at the end of October, when some of the sons, in going from their camp to the White Tank, found several pieces of gold-bearing stone on the surface of what afterwards became their Prospecting Claim. This site was vigorously prospected, and a shaft 30 feet in depth sunk on the reef.

Now that the field had been fairly well prospected by them they decided to peg out their claims and apply for them.

The pegging-out was done on the 16th December, 1893; first, the Prospecting Claim 960 feet by 400 feet, then Harry's Find as four men's ground; thirdly, the Pioneer Claim, also as four men's ground; fourthly, Christmas Gift as a prospecting claim, and lastly the Dead Rabbit.

On Monday, 18th December, Mr. Neeld went to Barmedman, reported his discovery, and put in his applications.

Ordinary applications were at first put in, but as the land on which most of the finds had been made formed part of Mr. Neeld's selection, it was necessary to exchange the original applications for applications for permits.

Men began to arrive on the night of 18th December, the day on which the discovery was reported, and by the end of January, 1894, there were about 500 men on the ground.

It was, however, not till March of the same year, when the results of the first parcels of ore crushed at the Barmedman Battery became known, that the big rush took place. By the end of that month about 10,000 people had arrived at Wyalong.

The importance of Mr. Neeld's discovery will be recognised when it is pointed out that in 1897 Wyalong produced more gold than any other mining division in the Colony. The production for that year was 34,370 oz., while Hillgrove, including Metz, which occupied second place, produced 31,886 oz. The total yield from the Wyalong Gold-field since its discovery at the close of 1893 up to the present cannot be less than 130,000 oz., worth more than half a million sterling.

2. History of the Development of Mining at Wyalong.

Ordinary quartz claims only were allowed in the early days of this gold-field. This arrangement gave very satisfactory results for a time, as it prevented the monopolisation of the ground by a few of the first comers, while it led to prospecting operations being vigorously carried on in all parts of the field by parties of working men.

The successful working of this arrangement was in no small measure due to the soft character of the ground, which over almost all parts of the field could be worked with pick and shovel alone down to a depth of at least 150 feet, thus making the sinking of shafts a very inexpensive matter. As a consequence of this many of the reefs have been profitably worked, which had the ground been hard would certainly have been abandoned.

No leases were granted until March, 1896, or more than two years after the discovery of the field. At first, however, the same conditions as to labour were enforced on the leases as on the claims. The object of this was to ensure that the miners already working on the claims should be retained on the leases, and its justification lay in the fact that the sinking was easy, and the leases were mostly still held by working miners.

When, however, the workings reached the hard country rock, and the mining expenses consequently increased, it was decided to allow the old leases to be surrendered and new leases with the ordinary labours conditions to be taken out.

As already mentioned, Mr. Neeld reported the discovery of gold at Wyalong in December, 1893, at which time a shaft 40 feet in depth had been sunk on his Prospecting Claim. There was exposed in this shaft a reef which varied from five or six inches in width at the surface to four feet, and the stone from it was worth from 1 oz. to $1\frac{1}{2}$ oz. per ton.

In the early part of 1894 stone was raised from several parts of the field and sent to the battery at Barmedman for treatment. The results of these first parcels of stone were made known in March, 1894, and caused the big rush. I quote from Mr. Slee's report* the results of these crushings, as they are historically interesting. They are as follows :—

Neeld and party		13	tons yielded	26 oz.	4 dwts.
Cassin	,,	12½	,,	9 ,,	3 ,,
Conway	,,	22	,,	103 ,,	5 ,,
Keith	,,	28½	,,	67 ,,	0 ,,
Neeld	,, (No. 2)	17	,,	72 ,,	16 ,,
Perry	,,	17	,,	42 ,,	18 ,,
Frazer	,,	10½	,,	39 ,,	6 ,,
Gorman	,,	37	,,	77 ,,	12 ,,
Smith	,,	6	,,	8 ,,	14 ,,
McMahon	,,	4	,,	10 ,,	0 ,,
Lawry	,,	14½	,,	14 ,,	18 ,,
Total		181½ tons.		471 oz.	16 dwts.

Thus 181½ tons of stone yielded 471 oz. 16 dwts. of gold, or at the rate of 2 oz. 12 dwts. per ton.

Experience has since shown that rich oxidised stone, as that treated at the Barmedman battery, cannot be satisfactorily treated by this process, and that where such material has been passed through a battery at Wyalong, there has been, almost without exception, a great loss of gold in the tailings. It is, therefore, necessary to point out that the results obtained from the first parcels of stone treated at Barmedman do not in all probability represent the true value of the stone, but that, at least, an ounce to the ton was left in the tailings.

At the end of 1894 the population of the two towns was 4,215. There were 300 claims at work, each consisting of four or eight men's ground. Of these, at least twenty-five were yielding more than payable returns.

During 1894, 6,358 tons of gold-bearing quartz were treated at Wyalong and Barmedman for a total yield of 9,649 oz., or at the rate of 1 oz. 10 dwts. per ton. This does not include the gold contained in the tailings, which, as their treatment later showed, were rich, and, if added, would make up the total contents of the stone treated that year to about 2 oz. per ton.

By the end of 1894 there were six crushing machines at Wyalong. These have since been reduced to four; and two chlorination works were erected, when it became recognised that chlorination was the most suitable process for the treatment of the rich ores.

During 1895 the raising of stone was carried on vigorously, and 15,634 tons were treated for a total yield of 24,497 oz., or an average of 1 oz. 11 dwts. per ton. This return does not include the contents of small parcels sent to Sydney and elsewhere for treatment.

The mine that produced the largest yield during this year was the Curra-jong, which produced 1,000 tons of ore, yielding 2,620 oz. of gold. During the same year, 1,213 tons from the White Reef Mine gave 2,447 oz.; 318 tons from the Welcome Stranger gave 1,782 oz., and 1,060 tons from the True Blue gave 1,426 oz. By the end of that year shafts ranging from 245 feet in depth downwards had been sunk on the various claims.

During 1896 there were 18,279 tons of stone treated for a total yield of 33,495 oz., or at the rate of 1 oz. 17 dwts. per ton. The deepest shaft at the end of that year was that on the Lighthouse Claim, which had been sunk to to a depth of 310 feet in solid granite. It was sunk to cut Klink's Reef, which, however, was cut at 230 feet from the surface, but not recognised as such at the time.

* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, p. 74.

The highest yield in 1896 was obtained from Bolte's Mine, now known as the Lucknow, viz., 2,506 oz., from 377 tons of stone, or at the rate of 6 oz. 13 dwts. per ton. From the New South Wales Mine 352 tons were treated for a yield of 2,338 oz.

Neeld's Chlorinations Works were started towards the end of 1896.

The production reached a maximum in 1897, being 34,370 oz. This was derived from three sources, viz., stone, "mullock," and tailings. "Mullock" is the name generally applied to the waste rock which is broken down when the reef is being taken out. In some of the Wyalong Mines, and especially in their upper or oxidised zones, the country rock bordering the reefs is much iron-stained, and often encloses thin veins or leaders of gold-bearing quartz. This is the so-called "mullock" that has been, and is even now being, put through the batteries. Its gold contents vary from a pennyweight or two to half an ounce per ton.

In 1897, 30,750 tons of stone were treated for a return of 33,900 oz., being an average yield of about 1 oz. 2 dwts. per ton, and 4,000 tons of "mullock" yielded 470 oz., or at the rate of nearly 2½ dwts. per ton. About 2,100 miners were employed on the field during the year, and the population was 4,200, or about the same as in 1896.

At the end of 1897 the deepest shaft was on the Lighthouse Claim; this shaft was 504 feet in depth, and is entirely in granite. The following were some of the highest yields obtained during that year:—Currajong Mine, 1,452 oz., from 1,200 tons; Klink's Mine, 1,877 oz., from 275 tons; Shamrock and Thistle Mine, 2,406 oz., from 492 tons; Lucknow Mine, 1,275 oz., from 324 tons; White Reef Mine, 1,264 oz., from 980 tons; and Perseverance Mine, 1,184 oz., from 418 tons.

During the past year, 1898, large quantities of stone and "mullock" have been treated at the different works, and large quantities of tailings at the cyanide works.

Up to the end of September there was treated at Gough's Battery 2,977 tons of stone, which yielded 1,877 oz. 14 dwts.; and 518 tons of "mullock" for 98 oz.; and at West's Battery, 2,438 tons of "mullock" for a return of 371 oz. 3 dwts. At Cox's Mill, up to 20th October, 1,688 tons of stone were treated for a return of 1,150 oz.

Since this report was written the total yield for 1898 has been estimated at 34,582 oz., being 212 oz. above that for 1897.

Developmental work is not being so vigorously carried on at the present time as one could wish. In too many of the mines it has been stopped when the vertical limits of the soft decomposed ground were reached. This is the case even with several of the mines that have yielded rich stone in the easily-worked ground, and have paid large sums in dividends. In many other cases, where the mines have only proved moderately payable, it has been impossible for the holders of the small claims to carry on expensive prospecting operations in the hard ground.

3. Previous References to the Wyalong Gold-field.

In May, 1894, a few months subsequent to its discovery, a geological examination was made of the Wyalong Gold-field by Mr. E. F. Pittman, Government Geologist.*

Two reports were furnished during the same year by the Chief Inspector of Mines.† In addition to the above, annual reports have been furnished by Mr. Warden Clarke for the years 1895–1898. (*See* Annual Reports on this Department for those years.)

* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, pp. 105–108; and Records Geol. Survey N.S. Wales, IV, pt. 2, p. 107.

† Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, pp. 24-25, also pp. 73-74.

PART II.

1. Physical Geography.

In and around Wyalong the surface of the ground is generally flat, with only a few isolated and widely-separated hills of very moderate height. The Government township of Wyalong stands partly on one of these low elevations, and a second is situated about half a mile to the N.E.

Other low rises occur at Pine Ridge and Pine Hill about 1½ miles S.S.E. of Wyalong.

In the area included in the map accompanying this report there are two main geological divisions; one is occupied by granite, and the other by highly altered sedimentary strata and intrusive hornblendic rocks.

The low hills are practically confined to the latter area, over which the rocks have not been so extensively decomposed as on the granite area. The granite over almost the whole of the gold-field has been decomposed to a mean depth of about 150 feet. The surface over this area is flat, or perhaps, more strictly speaking, is occupied by a flat, shallow depression, with an outlet in the south-easterly portion of the field.

The Wyalong Gold-field is situated within the drainage basin of the Lachlan River, and about eight miles from the water-parting which separates this basin from the adjoining one of the Murrumbidgee River. Wyalong is distant about forty-five miles from the Lachlan River, and about sixty-eight miles from the Murrumbidgee River, and is within a district remarkably free from watercourses. The Government township of Wyalong is sixteen miles N. 35° W. from Barmedman, and forty miles in a similar direction from Temora.

2. General Geology.

A. *General Remarks on the Geology of the District.*

The difficulty of making exact geological observations in the vicinity of Wyalong will be understood when it is explained that with the exception of the few widely-separated low elevations, such as the hill on which the hospital stands to the N.E. of Wyalong township, Pine Hill and Pine Ridge, the underlying rocks are nowhere visible at the surface. They are concealed by a covering of post-tertiary accumulations of red soil, &c., several feet thick. Our knowledge of them is mainly obtained from an examination of the surface soil, which occasionally indicates the nature of the underlying rock, and by openings, shafts, &c., made by miners in prospecting.

The difficulty of geological observation is increased by the absence of any exact knowledge as to the geology of the surrounding districts. In travelling from Barmedman to Wyalong—a distance of eighteen miles—no outcrops of rocks are seen.

In the vicinity of Wyalong there are, roughly, two main geological areas, which can be readily distinguished, and their boundary lines approximately shown. (*Vide* map).

One of these—the larger—is occupied entirely by granite, and in this the large majority of the reefs occur. The other, which seems to contain rocks of greater age than the granite, is occupied by highly altered sedimentary strata, and igneous rocks of intrusive character. The latter appear to vary in composition from intermediate to basic, and are also much altered.

The total area of the map presented with this report is thirteen square miles, of which more than two-thirds, or an area of about nine square miles, is occupied by granite, and the remaining four square miles by the sedimentary and associated intrusive rocks. The granite area occupies the whole of the western and the north-eastern portions of the map, the other area being confined to its south-eastern corner. The granite extends for miles in a northerly direction beyond the limits of the map, and probably, without a break, as far as Hiawatha—a distance of eight miles, in a direction N. 30° W. from Wyalong. At Hiawatha auriferous reefs have been quite recently discovered in the granite, which is apparently a continuation of the Wyalong mass. The granite also extends for some distance to the south of Wyalong; and westerly towards Yalgogrin the same rock extends continuously for two or three miles, and then in belts alternating with belts of altered sedimentary rocks.

The smaller area appears to be occupied by altered sedimentary strata and intrusive rocks. To what extent either of these exist there it is impossible to say, as over by far the larger portion of this area no exact knowledge of the underlying rocks can be obtained owing to the covering of red soil.

The intrusive rocks consist of diorites and hornblende schists. The latter appear to have been formed through the dynamic metamorphism of the former. A low ridge of these rocks starts near the hospital, and extends in a semi-circular form to the Marsden Road. A second ridge in the south-eastern corner of the map, including Pine Hill and Pine Ridge, is very largely occupied by these hornblendic rocks. Enclosed in the last-mentioned mass of hornblendic rock are three narrow belts of highly altered sedimentary rocks. One of these extends down Pine Ridge in a N.N.E. direction. It is about seven chains wide, and consists of slates and quartzite. A reef extends along the eastern margin of this belt near its junction with the diorite. This belt can be followed for about ten chains down a narrow spur from the main ridge, its further extension being hidden by the superficial deposits of red clay, &c. A second development of sedimentary rocks occurs forty chains to the east of the first; it has a northerly trend, is ten chains wide, and consists of bluish-grey schistose slate.

A third band, whose width is not known, occurs near the Barmedman Road, and twenty chains N.E. of Pine Hill. The order of appearance of these rocks would seem to have been as follows:—In the first place the sedimentary rocks were formed, these were later intruded by the diorites, which became partly converted into hornblende schists, and, lastly, the granite was intruded alike into the sedimentary and diorite rocks.

The deduction as to the granite being of newer age than the diorites is based on the following facts:—

(1.) The close association of the diorites with the oldest rocks—the sedimentary strata.

(2.) The apparently greater metamorphism of the diorites than the granite. The former are frequently found converted into hornblende schist.

(3.) Although the actual junction line between the granite and the diorites is nowhere visible, still in two places small felspathic veins, apparently intrusive, were noticed in the diorite in the vicinity of its junction with the granite. These two dykes are in all probability offshoots from the granite mass, which have been thrust into the diorite.

B.—*Sedimentary Rocks.*

(*a*) Recent and Pleistocene.

Comprised under this heading are the most recent accumulations, which consist for the most part of red soil, with fragments of quartz and small nodules of ironstone.

Almost the whole area of the gold-field is occupied by these loosely aggregated sandy and clayey materials, which owe their origin largely to the decomposition and disintegration *in situ* of the underlying granite and diorites. The prevailing red colour of these deposits, as of most similarly coloured materials, is due to the presence of larger or smaller quantities of oxide of iron. This is derived from the iron-bearing minerals, biotite and hornblende, which occur in the granite and diorites, and impart to them their dark colour. The decomposition of these minerals sets free the oxide of iron.

This red colour of the surface soil is, perhaps, more characteristic of regions having a dry climate than in moist regions, for in the latter the decaying organic matter has a bleaching effect, due to the reduction of the ferric oxide and its partial removal in a soluble form. Part of the oxide of iron has separated out in the form of small ironstone concretions, which present a rounded pseudo-water-worn appearance, due to their mode of origin. The red colour of the soil is, on the whole, more pronounced and deeper over the area occupied by the diorites and hornblende schists than over the granite area. This arises from the larger percentage of iron in the former rocks.

Angular fragments of quartz are very numerous, especially in the neighbourhood of the reefs. In the absence of well-marked outcrops it was the presence of these fragments that led to the discovery of gold at Wyalong. Small rounded pebbles of quartz occur on the surface in several places. They were particularly noticeable on the mallee flat which extends between the township of Wyalong and Pine Ridge. Although during heavy rain water evidently flows over this flat, there does not appear to be any depth of deposit there or any accumulation of gravel, but the loose rounded stones are scattered irregularly over the surface and through the red soil.

These surface accumulations are sometimes clayey, as on the mallee flats, and sometimes sandy. The sandy portions occur especially on the sides of the gentle slopes, from which the lighter clayey particles have been largely removed by wind and rain.

Besides the concretionary pebbles of ironstone referred to above and known as "ironstone gravel," there are other masses of a concretionary nature which consist of varying proportions of the carbonates of lime and magnesia. These occur especially in the subsoil over the decomposing diorites. The decomposition of the hornblende and felspar of these rocks sets free lime and magnesia, which become readily converted into carbonates by the absorption of carbonic acid gas, which is carried down by rain from the atmosphere. Ordinary hornblende contains about 19 per cent. of magnesia and 14 per cent. of lime. Such concretionary masses were not uncommon in some of the auriferous leads in the Colony where these leads overlay dioritic or andesitic rocks. They occurred at the base of the wash or in the decomposed country of the "bed-rock," and were known to miners as "clinkers."

(*b*) Silurian (?).

There appears to be but a very small development, in the vicinity of Wyalong, of these ancient sedimentary rocks. The existence of three narrow belts has already been noted and their positions described. They consist of highly altered sedimentary rocks, schistose slates, and quartzites, which have undergone considerable alteration. No fossil remains have yet been found in any of these sedimentary beds. It is highly probable that all traces of fossils have been obliterated during the alteration of the rocks. In the absence of fossils it is impossible to determine their exact geological age. On other evidence they may be provisionally classed as Silurian. The comparatively recent discovery of Lower Silurian fossils in rocks in two localities in the Colony, viz., at Tomingley, near Peak Hill, and in the parish of Alexander, county of Wellesley, and near the Victorian border opens up the possibility of such strata as those at Wyalong being Lower Silurian and not Upper Silurian, as the practice has previously been to call, provisionally, large areas of rocks in the western portion of the Colony, which, as yet, have furnished no fossil evidence as to their true age.

Some of the sedimentary rocks near their junction with the dioritic rocks contain epidote; the presence of this mineral is evidently due to chemical changes produced by the intrusion.

C.—*Eruptive Rocks.*

To this class belong the granite and diorites. The most important rock, from an economical point of view, is certainly the granite, which contains nearly all the gold-bearing veins worked in and around Wyalong.

The probable extent of the granite, and its relation to the area occupied by sedimentary rocks and the diorites, have already been described.

Along the main lines of reefs the granite has been considerably crushed.

The crushed material of these zones is locally known as the "formation," and the space occupied by it as the "channel."

These local terms will be occasionally employed in describing the reefs.

When seen in mass the granite exhibits a distinctly gneissose appearance. In places near the channel the intense pressure to which the rock has been subjected has produced a distinctly schistose structure. In these cases the rock is sometimes wrongly called by miners a slate. The mineral-bearing solutions, which have circulated through these crushed zones of rock and deposited the minerals of the veins, have produced chemical changes in the granite, which impart to it a dull green colour. The rock so acted upon is frequently called "serpentine" by the miners; to this rock it bears but a superficial resemblance, but differs from it entirely in chemical composition.

The alteration produced by the mineral-bearing solutions extends for some distance into the walls of the lodes, and when met with in deep underground workings is a sure sign of the proximity of a crack or fissure, through which the solutions have travelled. Sometimes in the solid granite a little vein of quartz, perhaps not more than an eighth of an inch in thickness, is bounded on each side by a band of altered rock several inches in thickness. This is the same phenomenon as is met with in large reefs and lodes, where the ore-body is bounded on each sides by a strip of altered rock, usually softer than the unaltered country-rock, but occasionally harder by the deposition of secondary silica.

This alteration is, of course, quite distinct from that almost universally met with in the upper portions of lodes and the surrounding rocks, where water charged with carbonic acid gas, organic acids, &c., percolates through the rocks, and accumulates at a certain level known as the water-level. The effects of this percolation downwards of water from the surface is to soften and decompose the country-rock, and to produce great changes in the mineral contents of the lodes.

To this must be ascribed the decomposition of iron pyrites in the Wyalong reefs with the production of ironstone and gossan, and accompanied by the setting free of gold in a fine state of division.

The granite has been softened and decomposed over the Wyalong Goldfield to a mean depth of about 150 feet, and down to that level it was capable of being worked by pick and shovel alone.

The undecomposed granite is a medium-grained holocrystalline rock of a mottled grey and black appearance. It has a distinctly gneissose structure, which is especially well-marked in large specimens; the dark constituents, hornblende and biotite, have a roughly parallel arrangement, thus imparting to the rock a distinctly banded structure. Irregular patches, varying much in size and darker in colour than the general mass of the rock, are not uncommon. These, which graduate into the surrounding rock, are apparently more basic in composition, and finer-grained than the rest of the rock.

Such masses are original, and would seem to have become separated out during the cooling of the magma. The minerals present in the granite are felspar, quartz, hornblende, biotite, and in much smaller quantities apatite and epidote.

The following analysis of a typical sample of the rock taken from the Klondyke Mine was made in the Departmental laboratory.

The low silica percentage shows that this rock should be more strictly termed a quartz-mica diorite; but the term granite has been used throughout this paper in its popular sense:—

ANALYSIS.

Moisture at 100° C.	0·13
Combined water	0·73
Silica (SiO_2)	58·93
Ferric oxide (Fe_2O_3)	1·73
Ferrous oxide (FeO)	5·01
Manganese oxide (MnO)	trace
Alumina (Al_2O_3)	17·48
Lime (CaO)	7·08
Magnesia (MgO)	4·33
Potash (K_2O)	1·34
Soda (Na_2O)	2·91
Titanic acid (TiO_2)	0·52
Vanadium pentoxide (V_2O_5)	strong trace
Phosphorus pentoxide (P_2O_5)	0·14
Sulphur trioxide (SO_3)	absent
	100·33

Perhaps the most interesting feature about the microscopic structure of this rock—at least from a mining point of view—is the existence of lines of crushing, along which the quartz is highly crushed, and presents the appearance, almost, of having flowed round the other minerals. The biotite mica is also drawn out and contorted. The analogy between these lines of crushing and the crushed zones, which form the so-called "formation" of the miners, and contain the rich gold-bearing veins of quartz, &c., is evidently very close. Both, in all probability, owe their origin to the same cause, viz., lateral pressure.

A rock whose field-relations to the granite and diorites I was unable to satisfactorily determine is typically developed on the hill on which the house occupied by Mr. Warden Clarke stands. This rock, which has been identified as a norite by Mr. Card, seems to occur as a narrow zone separating the granite from the diorites. The first specimens of this rock were collected previous to my visit, and are said to have come from the hill just mentioned, which is about one mile north of Wyalong Post Office.

The sections of this rock show it to contain little or no quartz, a very large amount of felspar (plagioclase), and a considerable amount of hypersthene and hornblende. The specimens collected by myself from apparently the same mass contain quartz, felspar (plagioclase), a large amount of hornblende, and perhaps a small quantity of hypersthene.

This rock, therefore, differs in mineral composition from both the granite and the diorites.

An important feature of this rock, and one that seems to connect it with the granite, is the presence in it of veins of coarse pegmatite. These have all the appearance of having separated out before the consolidation of the mass of the rock.

The following is a brief description of the microscopic characters of some of the rocks, which is given for the information of those who are specially interested in this subject.

I have much pleasure in acknowledging the assistance of Mr. G. W. Card, A.R.S.M., Curator and Mineralogist, in the microscopic examination of the rock sections.

*Granite.**—Microscopic sections were cut from four specimens of the rock collected from four different mines. They are: 1889†—Welcome Stranger Mine, 134-foot level; 1888—Lighthouse Mine, 160-foot level; 3,228—Currajong Mine; ——(?)—Gorman's Claim, 225-foot level.

The essential constituents of this rock are felspar, quartz, hornblende, and biotite, and the accessory ones are apatite and epidote.

The felspar appears to be entirely plagioclase, probably oligoclase, no orthoclase or microcline being recognised in any of the slides. The crystals show multiple twinning; in many instances both the albite and pericline types are to be seen in the same individual. Zonal structure is not uncommon, several of the crystals having a core, in which secondary minerals due to alteration are present, surrounded by zones of comparatively clear felspar. This makes it probable that the felspars have been growing *in situ* since the consolidation of the mass. Some of the felspars are shattered, with slight displacement of the portions. Kaolinisation has not taken place to any great extent, and is most marked in the central (? older) portions of some of the crystals.

The hornblende is in part idiomorphic, and the cleavage is well marked in cross-sections. Two varieties of this mineral seem to be present; one usually with idiomorphic outline, and the other more massive, and of a darker colour, and strongly pleochroic, with tints varying from emerald green to a deep blue-green.

The mica, the ordinary dark magnesium variety biotite, is much distorted and bent, and has a disposition to run in bands. Much of the biotite has undergone alteration into a pale green, and even colourless variety, with loss of iron compounds.

Epidote seems to make its appearance as a result of the alteration. Quartz is present, but in distinctly smaller quantity than the felspar. The main feature of this mineral is its crushing. Even in ordinary light the quartz can be seen to be crossed by a number of narrow cracks, but under crossed nicols it almost invariably breaks up into numerous small areas with irregular outline, and accompanied by complete loss of optical continuity.

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* This name is used in its popular sense, but by many petrologists it would be more strictly called a quartz-mica diorite.

† This refers to the number in the official register of rock specimens.

The crushing has resulted in the production of granular aggregates, which seem to have flowed round the felspars and other minerals. The quartz is the only mineral in the slide which exhibits this intense crushing; the felspars, with their perfect cleavage, contrary to what might be expected, have not suffered to any extent. This is, however, quite in accord with general experience, viz., that quartz is one of the first minerals to disintegrate under pressure.

Apatite and epidote have been mentioned as accessory minerals. The former occurs only in small quantity, and appears in sections as small glassy crystals. The epidote is certainly a secondary mineral, and in the sections is wholly associated with biotite which is in an advanced state of decomposition. It occurs usually in elongated masses of irregular outline, which lie along the cleavage planes.

The epidote is bright yellow in section, is pleochroic, and polarises in very high colours.

Norite.—This is a holocrystalline rock, consisting of plagioclase, hornblende, hypersthene, and magnetite, with also small quantities of biotite and apatite. The plagioclase is the most abundant constituent; it is probably a lime-soda felspar, is very fresh, and shows multiple twinning extremely well, probably on the albite type.

There are numerous inclusions in the felspars, which on the whole have no definite arrangement. The felspars are not shattered, but there are indications of strain. Hypersthene is present as an original constituent; it occurs generally as grains with irregular outlines, but occasionally exhibits prismatic form. The following is a description of this rock, written by Mr. G. W. Card, A.R.S.M., in 1896*:—"The norite is a medium-grained dark-grey rock, having a specific gravity of 2·76, and a silica percentage of 50·60. The minerals present are plagioclase felspar, hypersthene, hornblende, magnetite, zircon, apatite, and probably quartz.

"The felspar, which is fresh and abundant, has not yet been determined. Twinning is almost entirely on the albite type; and the felspar is to some extent schillerized. Hypersthene is very representative, exhibiting the characteristic pleochroism, cleavage, outline and straight extinctions. A paramorphic (?) change to hornblende can be traced step by step from a peripheral fringe of fibrous material to crystals of hornblende containing residual hypersthene, and, by inference, to hornblende in which the transition is complete. There would appear to be a close analogy between the changes here referred to and those described by Williams and Chester in the norites of Baltimore and Delaware respectively. The hypersthene is traversed by deeply-stained cracks. The hornblende is generally green in colour, and exhibits well-developed cleavage cracks when of appreciable mass. It is probably entirely secondary."

Mr. J. B. Jaquet, A.R.S.M., refers† to a similar change in a rock from Kiandra, in which the "majority of the grains (of hypersthene) have partially undergone a paramorphic change, and are fringed with green hornblende."

Other specimens (Nos. 3,235, 3,238, and 3,233 in the Official Register), which I collected from the zone in which the norite occurs, are less basic, and may possibly represent intermediate types between the granite and the norite.

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* Records Geol. Survey N.S. Wales, V, Pt. 1, pp. 13-14.
† Records Geol. Survey N.S. Wales, V, Pt. 3, p. 117.

All these contain plagioclase felspar, hornblende, quartz, magnetite, and apatite; Nos. 3,235 and 3,233 also contain probably a little hypersthene, and Nos. 3,238 and 3,233 also a little biotite much decomposed.

In all quartz is present in appreciable quantity, and occurs in clusters of grains which have partly rectangular outlines, and polarise simultaneously in a manner somewhat resembling the behaviour of the same mineral in graphic granite.

In regard to the diorites, the sections show that some of the rocks are typical diorites, consisting of hornblende and plagioclase felspar, while others appear to mark stages in the formation of hornblende schist.

PART III.

Economic Geology.

1. *Absence of Alluvial Gold.**

The absence of alluvial gold at Wyalong is one of the most noticeable features of the gold-field, and one in which it differs from nearly all other large gold-fields of the Colony. The existence of so many rich veins at the surface makes it extremely probable that these veins have suffered denudation to some extent. Had the other circumstances therefore been favourable alluvial deposits would have been formed. In the absence of these deposits we must, therefore, conclude they have not been so. The unfavourable circumstances are—

(1.) The absence of hills and gullies, the country being flat, where natural sluicing operations could take place;

(2.) The small rainfall; and

(3.) The exceedingly fine state of division of the gold, which as set free would probably be scattered by the action of the wind and rain storms, which are so frequent in these regions. It is thus probably dispersed through the surface accumulations that cover a large part of the surrounding country.

2. *The Ore Channels.*

Reference has already been made to the nature of the ore channels in the remarks on the granite. The reefs usually occur in a zone of crushed granite; this is a constant feature on the main lines of reef. The width of these zones varies considerably; for instance, on the Mallee Bull line of reef it is as much as eight or ten feet wide in places, and narrows down occasionally to a foot or less. They seem to owe their origin to the force of lateral compression, and resemble shear zones.

3. *General Remarks on the Gold-bearing Veins.*

The gold occurs in a number of veins composed largely of quartz, and, in the upper zone above the water-level, ironstone with sulphide ores below.

The veins occur as a more or less parallel series with a general trend ranging, with one exception, from due N. and S. to 20°, or even occasionally 30°, to the E. of N. and W. of S. They dip easterly at varying angles. The sole exception to the general trend is found in the case of the Pioneer line of reef, which has a nearly due E. and W. trend and a northerly dip.

* *Vide* introductory letter. —E.F.P.

There are about a dozen of these lines of reef within an area of about one and a half miles square. Some of the most important of them have received names, as Klink's line of reef, Mallee Bull line of reef, &c.

The reefs are, on the whole, of small size, and may be said to vary in width from an inch or two to a foot or eighteen inches, occasionally becoming as much as three or four feet in thickness.

In many of the mines the mean thickness of the reef cannot be more than eight or nine inches, but in others it may be as much as one foot or eighteen inches. On some of the smaller lines the reef is enclosed by tight granite walls, but usually there is a zone of crushed material, and the reef occurs on either side of this, or even within it. Not uncommonly the reef splits up into several portions, of which one may occur on either foot or hanging wall, and the other somewhere within it. Frequently the crushed granite occupies the whole of the space, and no reef is present.

The veins are lenticular in character, pinching in and widening out very rapidly when followed either horizontally or vertically. Polished surfaces or slickensides are occasionally met with, as well as narrow veins of a black material, consisting of crushed iron pyrites. These phenomena make it clear that some movement has taken place since the formation of the reefs. Polished faces of quartz were noticed in the Klondyke Mine, and grooved and polished masses of iron pyrites in the Lucknow Mine, on which gold is often visible as a thin film.

The largest constituent of the reefs is, of course, quartz; but, especially in the upper zone, calcite and gypsum are also sometimes present in small quantities as gangue minerals.

The metallic minerals in the unoxidised ore consist principally of iron pyrites, with comparatively small quantities of galena and zinc blende, and in the oxidised portion ironstone or hydrated ferric oxide, and sometimes a little carbonate of lead (cerussite) is visible. Native copper with stains of the carbonites are also present in one or two of the reefs.

Quartz occurs chiefly as the white opaque variety, but is colourless and glassy in places. A dull, horny variety was also noticed in one or two reefs.

Opal is also present in the reefs. It is usually of a reddish-brown colour, due to the presence of ferric oxide, but sometimes it is opaque, white, or even occasionally clear and colourless.

In this mineral fairly coarse gold is usually visible. As far as I could learn, it always occurs associated with quartz and ironstone in the upper or oxidised portions of the reefs, and not in the unaltered portions below the water-level. The presence of ferric oxide in this opal, as well as the fact of its being confined to the upper portions of the reefs, point to the probability of its being deposited in the reefs from solutions percolating from the surface. The presence of fairly coarse particles of free gold in the opal is an interesting feature, as the gold in the rest of the oxidised ore, as well as in the sulphides, is in a very fine state of division. If the opal has been deposited from solutions percolating from the surface, the gold has been derived from the same source; its very fine state of division would favour its passing into solution.

The ironstone is evidently derived from the oxidation of iron pyrites, which latter is present in all the reefs below the water-level. The ironstone is often very compact and dense, and is usually very rich. This is so generally rich that stone containing much of it is always treated by chlorination, as experience has shown that a large portion of the gold cannot be saved by the ordinary battery treatment.

Small quantities of native copper are found in the Klondyke Mine near the base of the water-zone. It occurs chiefly in cracks in the quartz, forming thin, sheet-like masses on the faces of the quartz, from which it may be readily detached.

Below the water-level iron pyrites, galena, and zinc blende occur in the reefs. The two last-named are only present in small quantities. The iron pyrites, on the other hand, is occasionally present in small veins from an inch or two to a foot in thickness, in a fine-grained, compact form. Veins of this mineral with small quantities of galena and zinc blende were being worked, at the time of my visit, in the Lucknow Mine. This ore was very rich, and went in bulk from 20 to 25 oz. of gold to the ton.

The most important constituent of the reefs is the gold. It is almost invariably present in a fine state of division. This remark applies to the ore from both the oxidised and sulphide zones. In the upper or oxidised zone through which surface waters have percolated, converting iron pyrites into ironstone and liberating the gold present in the sulphide ore, the latter is usually so fine that, even in rich ore, it is not readily noticeable except by the aid of a pocket-lens. As an exception to this rule, in one or two mines comparatively coarse gold has been found in the white quartz. This was notably the case in Stanley's Blow Mine, but also to a smaller extent in the Klondyke and Santa Claus Mines.

So closely associated is the gold with iron pyrites in the lower levels in the Wyalong mines that the presence of the latter is an almost infallible sign of their richness.

4. *Detailed Description of the Mines.*

It is now proposed to give a detailed account of the most important mines at Wyalong. The reefs have, on the whole, been found to run in well-marked lines, along which the different mines are situated. There are about a dozen of these lines of reef to be made out; these will now be described commencing from the most eastern one, or Klondyke line of reef.

Where returns from the mines are given, their absolute accuracy cannot be vouched for, as I have had to rely upon the figures given me by mine-owners and others interested in the mines. In the absence of legislation to compel mine-owners to furnish correct statements showing the yields from their mines there are no official records from which this information can be obtained. In many cases the figures given are incomplete. In the case of one of the most important mines on the field, viz., Neeld's Mine, the owners refused to furnish me with the information.

Klondyke Line of Reef.

This is the most easterly line of reef; it has been traced for a length of about fifteen chains, and has been worked principally in the Klondyke Mine. It has been traced northerly into Gatlan's lease, and southerly not beyond M. T. 217, unless a reef, which outcrops near the eastern boundary of G. L. 37, and which is being prospected by the United Australian Exploration, Ltd., is a continuation of it.

Klondyke Mine.—This is the only mine of any importance on this line. It is owned by Mr. Tyler. The reef in this mine, which has been opened up to a depth of 260 feet, is one of the few examples on the field of a true quartz reef, consisting, as it does, of a vein of quartz filling a fissure in the granite and bounded by well-marked walls. It strikes in a direction 30° E. of N.

and W. of S., and underlies at a steep angle to the east. In the last 100 feet, viz., between the 160- and 260-foot levels, the reef is practically vertical. Water was met with at 140 feet from the surface.

In the northern end of the mine there are two reefs above the 160-foot level, which junction at that level and extend downwards as a single reef. The eastern of these two branches dips at an angle of about 1 in 3, while the western one is nearly vertical. In the southern part of the mine there is a single reef down to 220 feet, where it splits into two portions. The accompanying section in the plane of the reef (fig. 1) shows a rich shoot of

Klondyke Mine.

Section along reef.

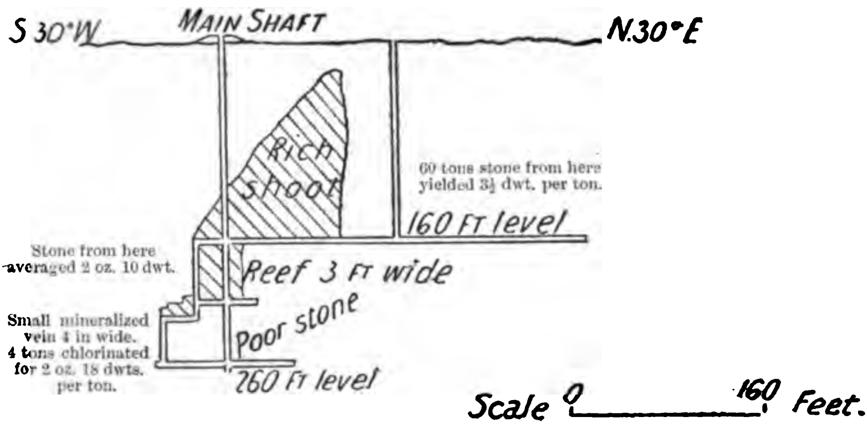

Fig. 1.

stone 120 feet long at the 160-foot level. This shoot has not yet been located at the 260-foot level. Immediately below the 160-foot level and north of the shaft, a reef 3 feet wide was exposed, the stone from which was expected to yield at least 2 oz. to the ton. At the bottom level north of the shaft the drive has been put in along stone of poor quality. In the roof of this drive native copper could be seen in the quartz ; this was apparently always in the form of thin plates filling up somewhat rectangular cracks in the quartz. One piece given me by the manager is rectangular in shape, the two sides being about an inch in length and about an eighth of an inch in thickness.

The manager is strongly of opinion that the metallic copper was an unfavourable feature, and expected that when the copper disappeared the quality of the stone would improve. It may be so, but it is not clear how the presence of metallic copper could influence the gold contents of the stone.

In the south drive at the 260-foot level fairly good stone was met with, but the vein became split up. From one small vein about four inches in width, and carrying a fair amount of iron pyrites, four tons were taken and chlorinated for a return of 2 oz. 18 dwts. per ton.

The prospects of this mine are distinctly good, for the reef is a strong one, being one of the widest bodies of quartz in the Wyalong District, is well-defined, and should extend down to a considerable depth.

In 1897, 263 tons of stone were treated from this mine for a yield of 432 oz.

Gatlan's Lease.—The Klondyke reef has been traced into this lease (G. L. 47), and stone taken from it near the boundary is said to have been crushed for a return of 16 dwts. per ton. Near the north end of this ground a shaft has been sunk to a depth of eighty feet, and the reef was cut at the 50-foot level by a short crosscut. The reef there appeared to be of little value, being represented by a narrow band of crushed and decomposed granite. A small reef has been cut two chains west of the Klondyke line in this end of the ground. It is very small, and no stone has been raised from it.

Miner's Right M. L. 102.

This is about twenty-two chains nearly due north of the Klondyke Mine. The reef runs in a N.E. and S.W. direction, and is nearly parallel to the Klondyke reef. It has been worked intermittently for some time, but was practically abandoned at the time of my visit, on account of the low yield obtained from the last parcel of stone treated, viz., 40 tons for 11 oz., or at the rate of 5½ dwts. per ton. The reef is only a short one. A northern extension of it was worked in the mine known as Irwin's Blow, and 32 tons from it were treated at Barmedman for a return of 3 or 4 dwts. per ton.

Shamrock Mine.

Another short reef occurs in this mine. This reef, which was discovered by Mr. S. Hennessey, is approximately parallel to the Miner's Right and Stanley's Blow reefs, and is six chains W. of the former, and four chains E. of the latter. It strikes about N.E. and S.W., and dips to the S.E.

About two years ago 16 tons of stone were raised from this reef, and yielded 3 oz. 14 dwts. per ton. This was taken from a lenticular patch about 60 feet long, and varying from 6 to 18 inches in width. The first crushing of 9 tons taken from near the surface contained some coarse gold, and yielded 2¼ oz. per ton.

The deepest shaft on this reef is 150 feet. Two men went into this mine recently with the object of removing the so-called "mullock" from the old stopes, but found it to be too poor.

Stanley's Blow Line of Reef.

The main workings on this line are thirty-five chains north of the Klondyke Mine.

To the north this reef splits up into two portions, which in Summergill's lease are about forty feet apart. To the south-west of Stanley's Blow the reef seems to continue on, but has not been worked to advantage. This line of reef was first found in Stanley's Blow Mine, where a large massive outcrop or "blow" of white quartz marked its presence at the surface. The greater part of this "blow" has been removed and crushed, and yielded fair returns; some of it contained coarse gold, the particles ranging in size up to that of grains of wheat.

Stanley's Blow Mine.—In this mine the reef averages about two feet in width, but it occasionally widens out to four feet. Several shafts have been sunk on the reef, the deepest being 190 feet.

Between 400 and 500 tons of stone have been crushed from this mine, of which 160 tons yielded at the rate of 6¾ dwts. per ton; 100 tons gave 8 dwts. per ton; 80 tons, 6½ dwts. per ton; and 45 tons, 7 dwts. per ton.

Recently the mine has been worked on tribute; the tributors have taken out about 43 tons, chiefly from the vicinity of the surface, which yielded about 7½ dwts. per ton.

Summergill's Lease.—Stanley's Blow reef is represented by two reefs in this mine. The two reefs are 40 feet apart. A crosscut from the bottom of the 150-foot shaft, sunk between them, intersects the western reef fourteen feet from the shaft. This reef varies from six to twenty inches in width, and 60 tons raised from it yielded 1 oz. 8 dwts. per ton.

A similar amount raised from the eastern reef gave 1 oz. 4 dwts. per ton.

Klink's Line of Reef.

This line crosses the road, connecting Wyalong and West Wyalong, about thirty-six chains west of the Klondyke Mine.

Gold was first discovered on this line of reef on the claim known as Harry's Find. Very good stone has been taken from this claim, but the mine that has produced by far the largest amount of gold is the one adjoining Harry's Find on the north, viz., Klink's.

This, which in the early days of this gold-field proved one of the richest lines, has not been traced with any certainty more than twenty chains. Its general strike is N. 10° E. and S. 10° W., and its dip is easterly. For a short distance the strike is nearly N.E. and S.W., and in the north end of Klink's Mine it seems to have taken a course somewhat west of north.

As on most of the other lines of reef, there is no well-marked outcrop, but below a foot or two of red soil it has been traced through Klink's Claim, where it is about seventy feet from the western boundary, through the centre of Harry's Find into the N.W. corner of the Victoria, and S.E. corner of the Frenchman's, and finally into the Catherine.

It has been doubtfully picked up in the adjoining claim to the south.

North of Klink's Mine the reef has not been followed, but in the adjoining claim, the Star of the East, two reefs have been found, either of which may be a continuation of Klink's reef.

N.N.W. of the Star of the East is the Ethel D., in which a band of crushed country "formation" has been met with. It is thought by some that this is a continuation of Klink's line of reef, but there is no evidence to show whether it is so or not.

The following mines were at work on this line of reef at the time of my visit, viz., New South Wales (the name applied to the two amalgamated mines formerly known as Klink's and Lighthouse), Harry's Find, Victoria, and Prince of Wales. In several others work had previously been done, but they were then idle; these are Star of East, Frenchman's, Catherine, Grand Junction, and Princess.

New South Wales Mine.—This includes the mines formerly known as Klink's and Lighthouse.

In the former mine (Klink's) the reef has been worked from the surface to a depth of 170 feet, and the ore obtained from it has been very rich. In the southern end of the mine the reef dips out of this ground into the Prince of Wales Mine, and in the northern end into the Lighthouse.

At about a depth of 170 feet from the surface there is a sudden change in the angle of dip of the reef (see fig. 2). From the surface to 170 feet the mean dip is about 45°; from that depth to where it was cut in the Lighthouse shaft the mean dip is as low as 17°. There was a very rich reef in this mine from the surface to 170 feet; from that depth downwards into the Lighthouse

New South Wales Mine.

Section across Klink's Reef.

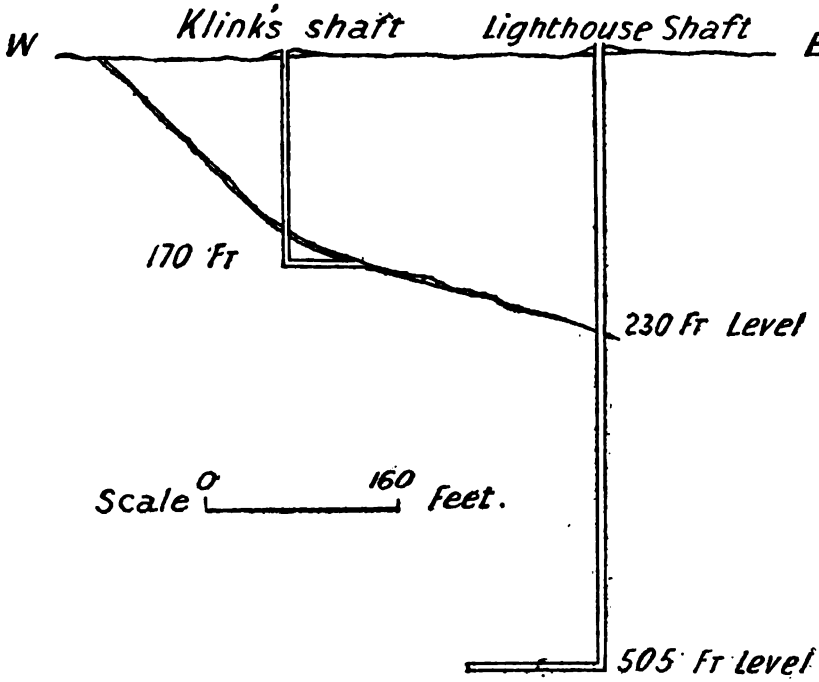

Fig. 2.

shaft no payable stone was met with, the reef between those two places being represented by a narrow zone of crushed and altered granite, with narrow lenticular bands of quartz. I regret my inability to get reliable information in regard to the returns from this mine, as it has been in the past one of the best dividend-paying mines on this gold-field.

Two parties of tributors were raising "mullock" from the old stopes in this mine. One party took out 218 tons of this material, which yielded 8 dwts. 19 grs. per ton, and 140 tons, which gave 5 dwts. 20 grs. per ton.

On the Lighthouse Claim a shaft was sunk to cut Klink's reef. This shaft has been sunk to a depth of 505 feet. A narrow band of crushed country was passed through at 230 feet from the surface; but as it was expected that the reef would not be cut in this shaft before a depth of 400 feet was reached, no notice was taken of this band. Later, Klink's reef was found to be continuous with this band met with at 230 feet,. the reef having suddenly become very flat.

Between the Lighthouse shaft and the 200-foot level, in Klink's Mine, the reef appears at intervals, and is occasionally as much as a foot in thickness. But in many places no reef is visible, the channel being entirely occupied by crushed granite. Levels were put in near the Lighthouse shaft, and 50 tons of quartz were raised from a reef, which averaged about 4 ins. in thickness.

The stone yielded 10 dwts. per ton, a return that was not payable, by reason of the small size of the reef and the difficulties of working it.

It is still thought probable by those interested in this property that the flat reef cut in the shaft at a depth of 230 feet is not the main reef, but that another will be found much steeper in dip, which was not cut in the shaft. In support of this view, they point out that at the bottom of Klink's 170-foot shaft, where the reef as exposed suddenly flattens, the country is much disturbed, making it possible that the main reef has been missed in this disturbed country, and that what has been followed is only a flat offshoot. It is also pointed out that in the Star of Peace Mine two reefs were found, of which the western one had a much steeper dip than the eastern.

I saw no evidence of a second reef. This point will shortly be decided, for a crosscut to the west is being put out from the bottom of the 505-foot shaft.

This had been extended more than one hundred feet at the time of my visit, and no reef had been cut; another twenty or thirty feet more should definitely settle the question.

Harry's Find.—This adjoins Klink's on the south; it was originally taken up by the Neeld family, and has remained in their hands ever since.

The reef has been worked by tributors down to the 150-foot level, where it passes into the Prince of Wales lease.

The shoots of rich stone in this mine dip apparently to the north.

Victoria Mine.—This is on the south side of Harry's Find. The outcrop of the reef passes through the N.W. corner of the claim. Its general strike is nearly due N. and S., and its dip is easterly. The reef in this ground is very flat, dipping at a mean angle of about 30° between the surface and the 160-foot level. It varies in thickness from an inch or two to two feet, and averages about nine inches. Very good stone was obtained near the surface in the northern end of the ground; but at the southern end no stone of any value has been obtained below eighty-five feet. The reef below that level is a foot or more in width, and consists of hard white barren quartz highly charged with black oxide of manganese. Normal faulting on a small scale was visible in several places in the mine.

Prince of Wales Mine.—This mine is on a block claim adjoining Klink's and Harry's Find on the east. The original shareholders were Messrs. Sladen and Naylor, by whom the ground was taken up. The property passed into the hands of the present owners, the United Australian Exploration (Ltd.), in June, 1897, who are reported to have paid £4,000 for it. Mr. A. S. Boucher is the superintendent engineer, and Mr. J. Gunther, the manager. There are two working shafts; a main one, which is vertical to a depth of 275 feet, cut through the formation at 225 feet. The other shaft, sunk near the S.W. boundary of the ground, is vertical to 175 feet, and then follows the underlay a further distance of 285 feet. Owing, however, to the extreme flatness of the reef, the vertical depth gained by sinking the last 285 feet on the underlay is probably not more than 80 feet.

Levels have been opened up at 225 feet from the surface. The reef along this level varies from an inch or less to a foot in thickness, and averages about five or six inches. In many places no reef can be seen, only a line of fracture, with more or less shattered granite in it. The general strike of the reef at this level is N. 10° E. and S. 10° W., and the mean dip from the bottom of the 175-foot shaft to the lowest point reached cannot be more than 17°. In places the reef is quite flat.

There are about twenty tons of rich ore and ninety tons of second-grade ore at grass.

Santa Claus Line of Reef.

This line of reef is distant about six chains west of that just described, and, like it, has produced large quantities of rich stone. It has been traced for a distance of about forty-five chains. Its general trend is N. 17° E., and its dip is easterly.

The following mines are situated on it, viz.:—Santa Claus, Aladdin, Erin's Isle, Monte Christo, Shamrock and Thistle, Waratah, and Ante-up. Of these, by far the most important is the Shamrock and Thistle.

Santa Claus Mine.—This was one of the original discoveries of the Neeld family. The reef is small, and does not average more than 4 or 5 inches in thickness, and occasionally splits up into several smaller veins. Some beautiful specimens of coarse crystalline gold were found in vugs in a dense grey quartz at the 128-foot level, which is the greatest depth at which work has been done in this mine. A total of 443 tons of stone have been raised from this mine between the surface and the 128-foot level, and been treated for a total return of 680 oz., or at the rate of 1 oz. 11 dwts. per ton. The best return was from a parcel of 6 tons, which yielded 42 oz., or 7 oz. per ton.

There was practically no work being done at the time of my visit in the Aladdin, Erin's Isle, and Monte Christo Mines. They have all been worked down to the water-level, or about 150 feet, and the two last-named are said to have yielded fairly large quantities of payable ore.

Shamrock and Thistle Mine.—This was formerly known as Conway's Mine, after the name of its discoverer. Rich stone was met with in this mine at the very surface, and a rich shoot of ore has been worked continuously to the 230-foot level, and has been picked up at the 330-foot level (see figs. 3 and 4).

Shamrock and Thistle Mine.

Section along reef.

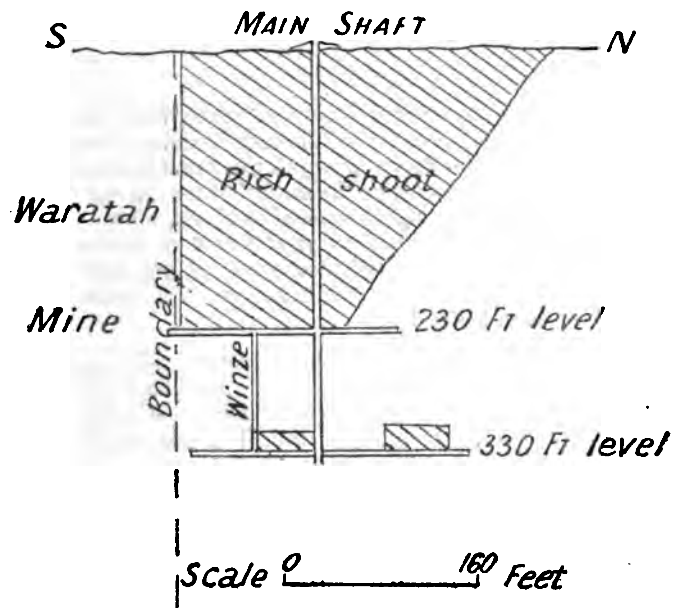

Fig. 3.

The mean dip of the reef between the surface and the 330-foot level is about 60°. Between the surface and the 230-foot level the ground has been worked out, but between that and the 330-foot level it has not been opened up to any extent. A winze fifty feet north of the shaft, connecting these levels, is said to have passed through good stone. In the bottom level

Shamrock and Thistle Mine.

Transverse section across reef.

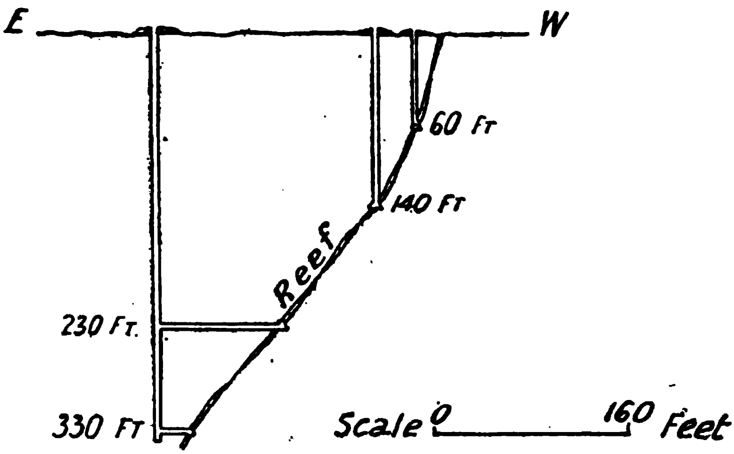

Fig. 4.

the rich stone seems to extend fifty feet south from the shaft, but a further thirty feet driven towards the Waratah boundary has exposed no reef of any importance. In the north drive, at the same level, no reef was met with for a distance of fifty feet from the shaft, but for the remaining sixty feet the drive passes through a highly mineralised reef, nine or ten inches in thickness. This stone is expected to yield 5 or 6 oz. to the ton. The rich mineralised ore from this level consists of glassy quartz, highly charged with iron pyrites and small quantities of galena. A sixth interest in this mine was recently sold for £1,750.

Waratah Mine.—This mine adjoins the Shamrock and Thistle on the south. The strike of the reef is N. 7° E. and S. 7° W., and the dip is easterly. The average width of the reef is about four or five inches, but occasionally it widens out to three feet. Some rich stone has been raised from this reef between the surface and the 215-foot level.

Ante-up Mine.—This adjoins the Waratah on the south. A rich shoot of stone was met with about forty feet above the 160-foot level (see fig. 5). The reef is small, like most of the reefs of this gold-field. This mine has produced 253 tons of stone, which yielded 546 oz. of gold, or at the rate of 2 oz. 3 dwts. per ton. The best return was obtained from 6 tons 14 cwt. of stone, which gave 8 oz. per ton.

There is a short line of reef running about midway between the Santa Claus and the Mallee Bull lines, on which the Young Australia Mine is situated. The reef in this mine has been sunk on for a depth of 230 feet. In the

Ante-up Mine.

Section along reef.

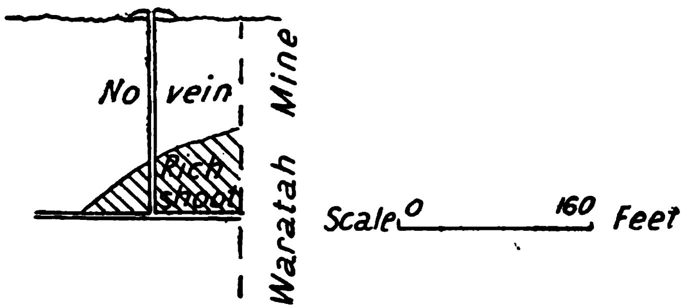

Fig. 5.

bottom it is well defined, and dips at an angle of about 80 degrees to the east. The returns from this mine are 103 tons of stone, for a yield of 163 oz., or at the rate of 1 oz. 12 dwts. per ton. Some of the stone yielded as high as 6 oz. per ton.

Mallee Bull Line of Reef.

This is undoubtedly the most important line of reef in the Wyalong Gold-field.

This line crosses the road connecting the Government township of Wyalong from West Wyalong, about one and a-half mile west of the Wyalong Post Office. It has been worked at intervals for a length of nearly one hundred chains, and on it are situated the richest mines of the field. It apparently gives off at the surface two important branches, one in Neeld's Prospecting Claim and the other in the True Blue Mine. The general strike of the main reef is N. 20° E. and S. 20° W., and its dip is easterly. The reef does not extend continuously from one end of the line to the other, for there are gaps where no reef is visible. What does persist from one limit to the other is the zone of crushed and altered country rock locally known as the formation. This can be traced throughout, and in some of the mines where a regular quartz reef has not been met with, as in the Brilliant, this zone is strongly developed, and often from six to eight feet wide. The average thickness of this reef is approximately about fifteen or eighteen inches. It widens out to two or three feet occasionally, and in one or two places to six feet or more, but it pinches in often to a few inches.

As to the value of the stone, it is as variable as the width. The richest ore has been obtained from the Lucknow Mine, from which bulk samples have been raised which have yielded as much as 25 oz. of gold to the ton.

From other portions of the reef along the line returns as low as 2 or 3 dwts. have been obtained. It is a pretty general rule along this line of reef that where ironstone or iron pyrites occurs in the stone in large quantities the stone is sure to be rich. The richest ore, viz., that from the Lucknow Mine, consisted of solid iron pyrites. As might be expected, the pyrites from the different mines, though usually rich, varies considerably in value; thus some fragments from the Lady Hampden Mine, which resembled the 20-oz. stone that was being raised in the Lucknow Mine, on being assayed were found to contain only 3 oz. 14 dwts. per ton.

Of the two principal branches given off from the main reef, the northern one leaves it about the middle of Neeld's Prospecting Claim, and extends for about ten chains in a north-easterly direction into the Lady Grace Claim. The other branch breaks away from the main reef in the True Blue ground and extends for at least twenty chains in a nearly due south direction.

On this latter branch the Junction Mine is situated.

On the main line of reef are Neeld's Mine (the prospector's), and to the north of this the Bantam, Lucknow (formerly known as Bolte's), Daisy, and Ironbark Mines; and south of Neeld's are the Lady Hampden, Brilliant, Mallee Bull, True Blue, Grand Central, Mallee Cow, Empire, Perseverance, Ledger, and Maiee Mines.

Of these, the most important are Neeld's Lucknow and True Blue Mines.

Gold was discovered on this line first in Neeld's Prospecting Claim; this has proved to be the most important discovery made by the Neeld family at Wyalong. This line of reef has been the most productive on the gold-field, and there is every probability that it will prove the most permanent.

Neeld's Mine.—This mine is, perhaps, without exception, the richest on the gold-field. The general strike of the reef is about N. 12° E. and S. 12° W., and the dip is easterly about 70°. A main vertical shaft was sunk to the east of the outcrop; this is forty feet east of the reef at the 100-foot level, and fifteen feet east of it at the 200-foot level. The sinking of this shaft was being proceeded with. In the vicinity of the underlay shaft, which is four chains south of the main shaft, a branch comes off from the main reef and extends in a north-easterly direction into M. T. 103, lately known as the Lady Grace Claim. This branch has been worked down to a depth of 160 feet chiefly by tributing parties of miners. At the 200-foot level, the main reef, which is there about two feet wide, is separated by twelve or thirteen feet of more or less crushed granite from a small reef a few inches in width. At thirty-five feet south of the crosscut a small vein branches off from the main reef and traverses first a S.W. and then S. 15° W. direction. A drive sixty feet in length has been put along this branch, which varies from a few inches to a foot in width, and consists of hard, white quartz, which assays up to 1½ oz. per ton. Near the northern end of the mine rich stone has been obtained from the surface down to the 100-foot level; this yielded from 2 to 15 oz. per ton, and averaged 4 oz. per ton. In the stopes above the 200-foot level in this end of the mine a reef which was as much as five or six feet wide in places was being worked, and very rich stone was being raised from it. In the southern end of the mine the ore seems to be on the whole much poorer, and was being partly worked by tributors; but in this end of the mine a rich shoot of ore was being opened up at the 200-foot level at the time of my visit. More than 2,500 tons of stone were at grass, which would yield from 8 dwts. to 10 or 12 oz. to the ton.

The accompanying section (see fig. 6) along the line of reef in this and adjoining mines to the north shows the approximate size and positions of the

Mallee Bull Line of Reef.

Section along line of reef in Neeld's Prospecting Claim and Bantam and Lucknow Mines.

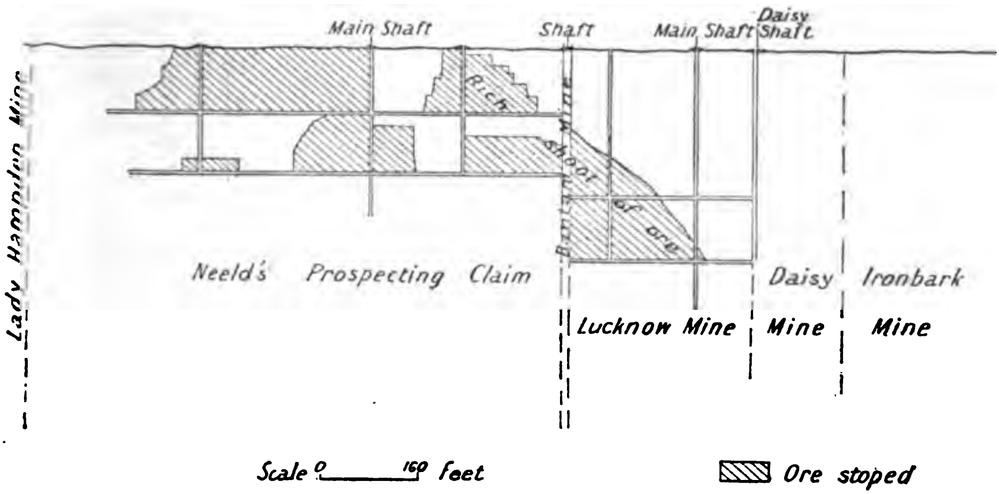

Fig. 6.

ore-bodies as at present exposed in these mines. The rich shoot of ore worked in the north end of Neeld's Mine appears to be dipping to the north, and to be continuous with that worked in the Bantam and Lucknow Mines.

Bantam Mine.—This is only a narrow strip of ground, seventeen feet wide, which separates Neeld's from the Lucknow Mine. It has lately been amalgamated with the Lady Grace, which is a block claim on the east, and into which the reef will probably extend at a depth. The amalgamated properties are now known as the Bantam Proprietary. A shaft has been sunk on the Bantam 406 feet in depth; for the first 125 feet it is vertical, and on the underlay for the remainder of the distance.

This mine has been in the hands of the present owners only since the beginning of this year; they paid £750 for it. Between February and August of this year £4,400 has been taken out of the mine, and £2,500 paid in dividends. About £2,000 has lately been spent in equipping the mine with haulage machinery and in cutting down the shaft.

Lucknow Mine.—This mine adjoins the Bantam on the north. A vertical shaft has been put down to the east of the outcrop to a depth of 336 feet.

The rich stone was not met with in this mine until a depth of 180 feet had been reached. At the time of my visit the payable stone had been worked out between the surface and the 236-foot level, but very rich stone was being raised from the stopes above the 336-foot level. This rich stone extends from the main shaft south to the Bantam boundary.

Some very valuable parcels of ore have recently been sent to Dapto from this mine. Of one parcel of 52 tons, 25 tons of first-grade ore yielded 23 oz. 13 dwts. per ton, and 27 tons gave 8 oz. 1 dwt. per ton.; of another parcel of 45 tons, 15 tons yielded 22 oz. 4 dwts. per ton; 7 tons, 7 oz. 1 dwt. per ton; and 23 tons, 4 oz. 13 dwts. per ton.

From the beginning of 1895 to October, 1898, the following returns have been received:—

	tons	cwt.					oz.	dwts.	grs.
	171	2	treated at	Clyde Works,	for	....	791	5	0
	5	4	,,	Footscray	,,	....	48	18	13
	12	1	,,	Wallaroo	,,	....	173	0	0
	23	6	,,	Bendigo	,,	....	80	0	0
	187	16	,,	Ballarat	,,	....	1,473	7	0
	17	18	,,	Climo's	,,	....	126	9	11
	366	10	,,	Dapto	,,	....	2,894	3	11
Total ...	783	17			,,		5,587	3	11

In addition to the above, 895 tons of lower-grade material were treated at the local batteries for a total yield of 639 oz. 16 dwts.

During the same period this mine has paid in dividends the sum of £12,545.

Daisy Mine.—This adjoins the Lucknow on the north. A shaft has been sunk close to the Lucknow boundary to a depth of 340 feet, and is vertical for the first 100 feet and on the underlay for the remainder of the distance. No reef of any value has yet been met with.

At the 300-foot level a drive was put in to the north on a very narrow vein, from which half a ton of stone was obtained, of the value of 6 oz. to the ton. The shaft is being sunk in a crushed zone of country rock 3 to 4 feet wide. An important point in the future prospects of this mine is the possibility of the rich shoot of stone now being worked in the Lucknow Mine dipping northwards into the Daisy.

It will be seen from the section previously referred to that the northern boundary of this rich shoot appears to be dipping to the north. If this dip is maintained, and the shoot continues downward, it should be met with in the Daisy Mine at from 100 to 150 feet below the present level of the Daisy shaft.

Ironbark Mine.—In this, which adjoins the Daisy on the north, the existence of two reefs has been proved. The deepest shaft is 251 feet in depth. At the 200-foot level there is a strong formation, which is as much as six or seven feet wide in places. At the 80-foot level there is a reef at least two feet wide, but the stone is of very low value. Twenty tons of stone were raised from near the surface, and yielded about 5 dwts. per ton. This seems to be the average value of the stone opened up in this mine.

This line of reef has not been traced any further to the north.

Lady Hampden Mine.—This, which includes only a narrow strip of ground along the line of reef, adjoins Neeld's Mine on the south. The reef was cut in the shaft at 100 feet, and followed down to a depth of 204 feet. It was thought by the managers of this and the adjoining mine, the Brilliant, that the workings in these two mines were probably not on the Mallee Bull line, but on a branch from it. Until Neeld's reef has been traced into the Lady Hampden Mine it will not be possible to say whether this is so or not; but I am inclined to think they are on the main line. From this mine 128 tons of stone have been raised and treated for a total return of 79 oz. 5 dwts., or at the rate of rather more than 12 dwts. per ton. The stone has varied in value from 4 dwts. to 2 oz. per ton. A sample of pyrites brought down by me for assay gave a return of 3 oz. 14 dwts. of gold per ton, and 3 oz. 0 dwt 23 grs. of silver per ton.

Brilliant Mine.—This mine includes the claims formerly known as the Brilliant and the Treasure. Prospecting operations have been carried on with remarkable perseverance, although up to the present no payable stone has yet been met with. A shaft about 400 feet in depth has followed down the zone of crushed granite, which varies from three to eight feet in width. Lenticular masses of practically barren stone have been met with, and some pieces of stone showing free gold were found in the bottom of the shaft; but they did not resemble the rich stone found in the other mines on this line.

Mallee Bull Mine.—A large amount of work, both sinking and driving, has been done in this mine without proving the existence of a payable reef. Near the surface loose lumps of rich stone were found, which were locally known as "spuds." These were evidently derived from the denudation of a rich vein in the vicinity, probably from the reef in the True Blue Mine. Seventy-three tons of these loose blocks were obtained, and yielded 128 oz. 8 dwts. of gold, or at the rate of 1 oz. 15 dwts. per ton.

Between the surface and the 170-foot level there are at least two reefs which are as much as two or three feet wide in places, but up to the present the stone in them has proved poor.

There has been raised from the reefs between the surface and the 100-foot level a total quantity of 347 tons, which yielded 159 oz., or 9 dwts. per ton, and 45 tons of second-grade stone, which gave on treatment less than 3 dwts. per ton. Mr. Channon has recently taken over the management of this mine; he proposes to experiment on the low-grade ore by dry crushing and cyaniding, and should this prove a failure further efforts are to be made to discover payable stone in the deep ground.

True Blue Mine.—This mine ranks next in importance to Neeld's and the Lucknow, at least on this line. The main Mallee Bull line of reef splits in this mine into two branches which diverge as they are followed southwards. The Junction is situated on the eastern one, and the Perseverance and Ledger Mines on the western one.

The two reefs have been opened up to a depth of 260 feet, and large quantities of stone have been stoped from them. They both dip to the east, the eastern one at a lower angle than the western; they are consequently becoming more separated as they are followed down. A winze was sunk on the eastern reef, 92 feet below the 260-foot level, and 30 tons of stone are said to have been raised from it which yielded 5 oz. per ton. Another winze was put down on the western reef from the same level, and to a depth of eighty-two feet. Nine tons from this winze are said to have yielded at the rate of 5 oz. 12 dwts. per ton, and 100 tons 17 dwts.; these parcels of stone came from a reef about 2 feet wide. I was unable to obtain the total returns from this mine.

Junction Mine.—This mine is situated on an extension of the eastern reef worked in the True Blue Mine. A vertical shaft cuts the reef at 315 feet from the surface. A large amount of rich stone has been raised from this mine, the full records of which I was unable to obtain. Three months previous to my visit 30 tons of rich pyritous stone were raised, of which 13 tons yielded 9 oz. per ton; 9 tons, 12½ oz. per ton; and 8 tons, 9½ oz. per ton. In addition to this 180 tons were treated at the batteries for a yield of 1 oz. 5 dwts. per ton. At the lowest level (350 feet) the rich ore seems to be extending into the adjoining claim, Maud's Jewel.

The mineralised reef in this mine varies from one to eighteen inches in width.

Napoleon.—Several shafts were sunk on this ground, the deepest being 150 feet, but nothing more than a narrow belt of crushed country rock was met with, in which very small veins existed. One ton of stone picked out from these veins yielded 14 dwts.

No reef of any value has been obtained in the Mallee Cow or Empire Claims. A small vein was cut in the former, from which 7 tons of stone were said to have been taken, and to have yielded 5 oz. per ton. In the Empire Claim a band of crushed granite, four feet wide, was driven on for a distance of thirty feet, but very little quartz was met with.

Perseverance Mine.—This mine has yielded a considerable amount of rich stone, and is said to have paid about £8,000 in dividends.

Work was suspended in this and the adjoining mine, the Ledger, and I was consequently unable to examine the workings in either of them.

In the Perseverance Mine a vertical shaft cuts the reef at 230 feet, and from this point it has been followed down to 280 feet. About 1,000 tons of quartz are said to have been raised from this mine, and treated for an average yield of about 2 oz. per ton. The shoots of rich stone are said to have dipped to the south in this mine.

Maiee Gold-mine.—This is the most southern mine working on this line of reef. A shaft 270 feet in depth intersects the reef at a depth of 250 feet, which is very small. In the south drive at the 270-foot level the reef is not more than a few inches wide.

Seventeen tons of stone were raised from this mine and treated for a return of 8 oz., or at the rate of 9 dwts. per ton.

Perry's Line of Reef.

This occurs about twenty-five chains west of the Mallee Bull line; there are only a few mines on it, and, with the exception of Perry's claim, they have not been payable. Only one mine was working on this line at the time of my visit; this was the Ready Money, which includes Perry's claim. Gold was first discovered on this line at Perry's claim, and was later found at intervals along it for a distance of thirty-five chains. The general trend is N. 25° E. and S. 25° W., and the dip is easterly and about 70°.

In the Ready Money Mine the reef is very small, only two or three inches thick, and occurs in a band of crushed granite two feet wide.

A small reef was cut in the Grand National Mine at 220 feet, but the only stone raised from this reef was 5 tons from near the surface, which yielded 16 dwts. per ton. In the Great Britain Mine the reef has been sunk on to a depth of 310 feet; it is rather small, but has yielded some good stone.

Another short line of reef occurs to the south of Perry's line; on it are the Central (formerly known as Pooley's) and Nil Desperandum Mines.

The reef or reefs, for in the Central there are several small veins, are small, but some rich stone has been taken out of them between the surface and about 150 feet.

Another short line of reef occurs ten chains west of the above; this is the Mouse Trap. The whole line was practically idle. The payable stone seems to have been removed from the surface to the 200-foot level. The reef is very small, and only averaged from four to six inches. The trend is N. 20° E. and S. 20° W., and the dip is easterly. The returns from the Mouse Trap Mine are 240 tons, treated by battery, for 415 oz., or 1 oz. 14 dwts. per ton; and 147 tons, treated by chlorination, for 881 oz., or 6 oz. per ton.

Currajong Line of Reef.

There are two reefs about 100 feet apart in the Currajong and Golden Fleece Mines, the two most important mines on this line. Their general strike is about N. 20° E. and S. 20° W., and the dip is easterly. The two reefs which occur in the Currajong Mine have not been traced with any degree of certainty north of that mine. It, however, seems probable that the main reef worked in the Hilderbrand, Yorkshire Lass, Two Up, and Dodger Claims is a continuation of the western reef of the Currajong Mine. To the south both reefs have been worked in the Golden Fleece and Keep-it-dark Mines.

Currajong Mine.—This is undoubtedly the most important mine on this line. There are two reefs—an eastern and a western one—both of which dip to the east. The main shaft, 310 feet in depth, is sunk between the two reefs, being eighty-seven feet east of the western reef at the surface, and twenty-seven feet east of it at the 310-foot level. The eastern reef is nearly vertical, being fifteen feet east of the shaft at the surface, twenty-two feet east of it at the 150-foot level, and twenty-five feet at the 230-foot level. (See Fig. 7.)

Currajong Mine.

Section across the reefs.

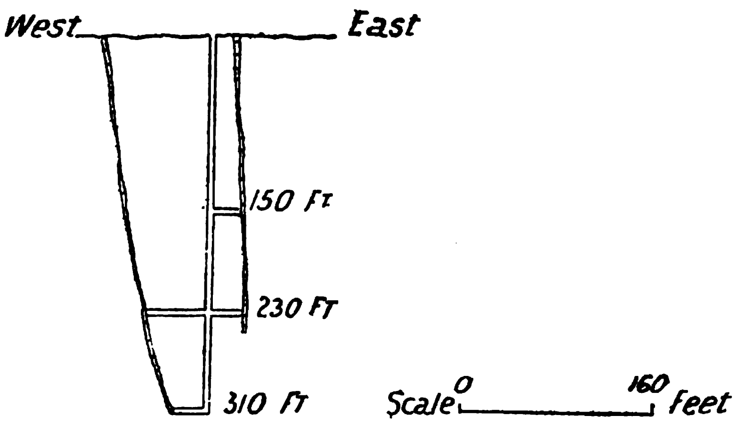

Fig. 7.

A large amount of stone has been raised from these two reefs. The western one is the richer of the two, and averages about nine inches in thickness.

This has been one of the most productive mines on the gold-field, and large dividends have been paid. I was unable to ascertain the amount paid previous to October, 1895, but since that date £13,700 has been received by the shareholders.

From August, 1897, to the present time, however, the proceeds from the mine have scarcely paid the wages of the miners employed. The mine is now being worked by two or three parties of tributors, who seem to be doing fairly well.

Hilderbrand's Mine.—This was a mine of some importance in the early days of the gold-field when rich stone was being raised from the soft ground.

There are at least three reefs, but they are all very small, and separated from one another by a few feet of granite. The stone has been stoped from this mine from the 150-foot level to the surface; from a vein three or four inches in thickness stone yielding 8 oz. to the ton was obtained. These small veins appear to extend northerly into the Yorkshire Lass, Two Up, and Dodger Claims, from all of which small quantities of payable stone have been raised.

Golden Fleece Mine.—This is south of the Currajong Mine, and in it the same two reefs occur that are found in the latter. Most attention has been paid to the western reef, which has been prospected to a depth of 320 feet.

Recently 107 tons were treated from this mine for a total yield of 67 oz., or at the rate of 12½ dwts. per ton but large quantities of stone have been raised from this mine of which I have no record.

Keep-it-dark Mine.—The Keep-it-dark Mine lies to the south-west of the above; in it are the same two reefs, with a third to the west of them. From this mine 643 tons of stone have been raised for a yield of 883 oz., or at the rate of 1 oz. 7½ dwts. per ton.

Other Lines of Reef.

Operator, Red Flag, and Wye's Mines.—In the extreme western portion of the gold-field there are several lines of reef, some of which have yielded large quantities of rich stone while they were worked in the soft ground. But as work was suspended in nearly all of them at the time of my visit I was unable to examine them, and therefore can give very little information about them. In the south-western portion there are at least three reefs to the west of the Currajong line. The following mines on these reefs have yielded rich stone in the soft ground, viz., Operator, Red Flag, and Wye's; but little or no work is now being done in them.

In the extreme north-western corner there are at least five more reefs in addition to those already mentioned. None of them are large, but they are rich in places, and have been profitably worked while the granite was soft.

White Reef and Welcome Stranger Mines.—The White Reef Mine has been a very productive one; but at the present time the reef is small and the ground is very hard. In the Welcome Stranger Mine there are two reefs, but only the western one has been worked, and that only to a depth of 150 feet, the extent of the soft ground. In the south end of this mine, near the 4Js' boundary, a show of rich stone 200 feet long was worked out to the surface; this seems to have dipped to the south. The average width of the reef was six inches. Between June, 1894, and December, 1896, 1,178 tons of stone were treated from this mine for a yield of 4,860 oz., or at the rate of 4 oz. 2 dwts. per ton. This mine has paid in dividends £2,000 per share, or £16,000 in all. No work has been done in the hard ground, and the mine is now idle.

Hidden Treasure Mine.—In the Hidden Treasure Mine three reefs have been found; two of these are identical with those which occur in the Welcome Stranger Mine, and the third appears to be that worked in the Three Star and Homeward Bound Mines. A vertical shaft has been sunk on one reef, and a second junctions with this at 140 feet, and at 200 feet another small vein joins it from the east. The mean width of the reef worked in the vertical shaft is about three inches, and the richest stone was taken from it between the 90- and 180-foot levels.

This mine was abandoned for about twelve months; but was taken up again in February of this year. Since that date 30 tons of ore have been treated for a return of over 53 oz., being at the rate of 1 oz. 15 dwts. per ton.

Gipsy Queen and Star of Peace Mines.—Good returns have been obtained from the Gipsy Queen and Star of Peace Mines, but I am unable to give the figures.

Louisa Claim.—The Louisa Claim has yielded but a small quantity of stone; 57 tons are said to have been treated for a return of 78 oz. 7 dwts., or 1 oz. 7 dwts. per ton.

Homeward Bound Mine.—In the Homeward Bound Mine two reefs have been worked—one near the eastern boundary of the claim, and probably identical with the rich reef in the Welcome Stranger Mine, and the other is the same reef as that worked in the Three Star Mine.

Practically, all the work has been confined to the soft ground. On the first-mentioned reef two shafts, each 140 feet deep, and 150 feet apart, have been sunk, and connected by a drive; and a winze has been sunk to a depth of forty-seven feet below this level. At least 271 tons of stone have been raised from this reef and treated for a return of 453 oz. 3 dwts., or at the rate of 1 oz. 13 dwts. per ton; and 61½ tons from the other reef yielded 102 oz., or 1 oz. 13 dwts. per ton.

Three Star Mine.—In the Three Star Mine good stone yielding 1½ oz. per ton was found near the surface; but at 60-foot level the reef became much broken up, and at 160-foot level the reef averaged nine or ten inches in thickness, being as much as two feet in places, and 15 tons from it at that level yielded 1½ oz. per ton.

As the prospects seemed good a vertical shaft was put down; this, at 250 feet, was eighteen feet from the reef. At that depth the reef was found to be very small, from an inch or two to eight inches in width, and was firmly attached to the walls. Some driving was done on it at the lowest level; but as the prospects were not encouraging it was discontinued, and the mine has been lying idle for about twelve months. From this mine 327 tons were raised and treated for a yield of 348 oz., or 1 oz. 1 dwt. per ton.

Hill Top Mine.—The most western reef worked at Wyalong is that in the Hill Top Mine. It has been worked at intervals for a distance of 25 chains. In the Hill Top Mine it has been intersected by a crosscut 22 feet long from the bottom of a vertical shaft 230-foot deep. At this depth a drive 40 feet long was put in along the reef, which was found to be very small and of low value. About 300 tons of ore are said to have been raised from this mine from stopes between the 130-foot level and the surface. This stone averaged about 1 oz. per ton, but some of it yielded as much as 6 oz. 8 dwts. per ton. This mine is now idle.

Sunny Hill Extended Mine.—South of the Hill Top Mine, and on the same reef, is the Sunny Hill Extended, which includes what was formerly known as the Sunny Hill and Democrat Claims. From the north end of this mine about 300 tons of stone have been raised and treated for an average yield of 1 oz. 2 dwts. per ton. From the south end 150 tons of ore were raised, of which 18 tons yielded by chlorination 6 oz. 12 dwts. per ton, and the remainder was treated by the battery for a return of 9 dwts. per ton. This mine has not been worked for eighteen months.

Pioneer line of Reef.—The only other reef that it is necessary to describe is the one which forms the solitary exception in having an east and west trend. This is the Pioneer line of reef, on which the first discovery of gold was made.

The reef has been worked at intervals over a distance of twenty-five chains. It has a general strike of W. 10° N. and E. 10° S., and dips to the north. It has been worked in the following mines:—The Easter Gift (formerly known as the Dead Rabbit), Christmas Gift, Christmas Gift Block, Great Southern, and Pioneer.

Easter Gift and Xmas Gift Mines.—In the Easter Gift Mine the reef averaged about nine inches in width, but in the lowest level it was not more than three or four inches. About 114 tons of ore have been raised from this mine for a yield of 160 oz., being at the rate of 1 oz. 8 dwts. per ton. In the Xmas Gift Mine the shaft is 240 feet deep, and the stone has been stoped out in blocks from 140-foot level to the surface.

The shoots of rich stone seem to dip westwards. In this mine, at the 240-foot level, the reef is on an average nearly three feet wide, but it is too poor to pay for its removal.

5. *Genesis of the Deposits.*

As regards the origin of the ore channels, I have already expressed the opinion that they are due to the shearing of the granite along a number of approximately parallel lines, by which the zones of crushed granite or "formation" were produced, and spaces, more or less lenticular in form, which have become later occupied by the veins.

The minerals filling the spaces and forming the veins have evidently been deposited from solutions which have circulated through them. But there is practically no evidence to indicate the ultimate source of the minerals, or to show whether the solutions that deposited them derived their contents from the immediately adjacent portions of the granite, or brought them up from some deeper-seated source, probably in the granite itself. What little evidence there is is in favour of the latter view, for the ascending solutions appear to have penetrated laterally for a short distance into the granite walls of the veins, to have altered the granite, and in some cases to have deposited minerals in it.

PART IV.

The Metallurgical Treatment of the Ores.

At the commencement of mining operations at Wyalong all the stone raised from the mines was sent to Barmedman, a distance of eighteen miles, for treatment by battery; but when the value of the reefs was proved it was not long before batteries were erected at Wyalong. It was not until considerable quantities of stone had been treated by the ordinary battery that it was found that this method was totally unsuitable for the treatment of rich ores; for it was found that a large quantity was going away in the tailings.

The subsequent treatment of these tailings by the cyanide method has been the source of great profit to the owners of Duncan's and Channon's Cyanide Works, who are said to have purchased large quantities of tailings at a merely nominal price, which contained more than an ounce of gold to the ton.

When the great loss of gold arising from the treatment of the rich stone by battery was recognised, chlorination works were erected.

There are at the present time, at Wyalong, three batteries, one Huntington mill, two chlorination works, and two cyanide works. All of these works were kept fully occupied during my visit. All were not, however, treating highly payable ore, as a considerable amount of so-called "mullock" was being put through the batteries while the cyanide works were almost wholly devoted to the treatment of tailings, of which large quantities had accumulated.

Of the batteries Nicolas and Reymond's is the largest; it consists of 22-head of stampers, two Frazer pans, and two concentrators.

Gough's battery consists of 15-head of stampers and shaking bubles. Between 1st January and the 30th September of this year 2,977 tons of stone were treated at these works for a return of 1877 oz. 14 dwts., or 12½ dwts. per ton, and 518 tons of mullock for a yield of 98 oz., or 3 dwts. 19 grs. per ton.

At West's battery, where there are 10-head of stampers, large quantities of "mullock" have been treated. This consists of low-grade material obtained from the dumps and from the old stopes in the mines. Material of this character naturally varies much in quality. From the beginning of the year up to the end of September 2,438 tons of this mullock were put through for a total yield of 371 oz. 18 dwts., or 3 dwts. per ton.

Mr. Cox has passed through his Huntington mill from the beginning of January to the 20th October of this year 1,688 tons of stone, which yielded 1,150 oz., or at the rate of 13½ dwts. per ton.

Wyalong Chlorination Works.—These were formerly known as Climo's works, as Mr. Climo was managing director at the time that they were erected; they are now owned by Mr. W. Sully.

They were started in 1895, but were not ready for the treatment of ore until the early part of 1897. They consist of a Krupp mill No. 6, a revolving roasting furnace, a cooling vat, 4 chlorination vats of a capacity of 24 tons each, and two cyanide vats of 45 tons capacity, also chlorine generators, &c. The present manager is Mr. Janitzky, and the accountant Mr. Shoobridge.

A very large amount of money has been spent on these works, but the results which have been obtained have not been altogether satisfactory. It seems doubtful whether the sulphide ores receive a sufficiently sweet roasting in the revolving furnace to enable a completely satisfactory extraction to be obtained. It has been found necessary in many cases to treat the material with cyanide solutions after their removal from the chlorine vats, in order to remove a further portion of their gold contents.

Stone, yielding from 1 oz. to 35 oz. per ton, has been treated at these works, in addition to 2,000 tons of tailings, varying in value from 5 to 25 dwts. per ton, and averaging ½ an ounce per ton.

At Neeld's chlorination works there is a Krupp mill with a reverberatory roasting furnace and nine chlorine vats. The capacity of this plant is about 40 tons per week.

Duncan's cyanide works have been established over two years. They are on the site formerly occupied by Gough's battery, where large quantities of rich ore were treated in the early days of the gold-field, with the production of rich tailings. These were acquired by Mr. Duncan, who has made large profits from the treatment of these tailings.

As the owner of this or other similar works do not give particulars of the amount and value of the tailings treated by them, no exact statement about these matters can be made. It is generally believed that a large part of these tailings have yielded more than an ounce of gold per ton. Concentrates ranging in value from 1 to 10 oz. per ton, and consisting largely of iron pyrites, have also been successfully treated at these works by the cyanide method.

A small plant was being erected at the time of my visit at these works to treat the raw pyritous ores by means of dry crushing and cyaniding.

I was informed that experiments had recently been conducted on the rich sulphide ores, with a view of ascertaining whether, by means of some modification of the cyanide process, these ores could not be more cheaply and advantageously treated by this method. I have been assured that on a small scale these experiments have yielded satisfactory results. Whether the gold is present in the free state or not in the sulphide ores is not known. If free, it must be in a very fine state of division, because gold is seldom visible in them. If it should prove possible to treat the sulphide ore successfully by the cyanide method, it will be a great boon to the field, as in nearly all the deep mines sulphide ores are making their appearance; and, as this method is a much cheaper one than chlorination, it means that ores which would not pay by the latter process would yield a profit by the former.

Some large parcels of rich sulphide ores, especially from the Lucknow Mine, have been smelted at Dapto, but the expenses are rather heavy, amounting to £3 15s. or £4 per ton.

Channon's Cyanide Works.—These works are on the site of an old roller battery, owned by Mr. Channon, which proved a failure.

There are three large leaching vats, of a capacity of 35 to 40 tons each. Zinc filings are used for precipitating the gold from the cyanide solutions.

About 10,000 tons of tailings have been treated at these works, from which £18,000 worth of gold has been obtained. The tailings have yielded, on an average, about 36s. per ton. There are still about 4,000 tons of tailings at the works, which it is expected will yield from 12 to 14 dwts. per ton.

The value of the tailings have decreased considerably of late, owing to the richer ore being treated by chlorination, and they do not now contain more than 6 to 8 dwts. per ton, while formerly large quantities contained as much as 2 oz. per ton.

The capacity of the works is about 150 tons per week.

PART V.

Other Auriferous Veins in the Vicinity of Wyalong.

All the reefs described in Part III occur within a tract of country about 120 chains square, and lie wholly within the area occupied by the granite.

Within the other geological area occupied partly by highly altered sedimentary rocks and partly by diorites passing into hornblende schist, auriferous reefs are not numerous, and only two have proved to be of any value within the area of the map accompanying this report. Of these, one is situated at Pine Ridge and the other on Pine Hill.

At Pine Ridge, which is situated about a mile and a half S. 20° E. of Wyalong Post Office, there is a band of altered sedimentary rocks, six chains in width, bounded on each side by diorite.

Close to the eastern side of this band is a quartz-reef, which dips to the east at an angle of about 80°. This reef has been worked for more than four years; but at the time of my visit only one claim was at work. I am unable to give the total yield from the Pine Ridge claims; but Mr. Leathley informed me that from his claim (M.T., 2) he had raised 101 tons of quartz, which yielded 111 oz. 11 dwts., or at the rate of 1 oz. 2 dwts. per ton. These figures do not include the contents of the blanketings and tailings, nor the return from the seventy tons of stone treated in the early days of the field, which was very unsatisfactory.

The reef averages about six inches in thickness; it widens out occasionally to about six feet, but where wide is usually of low value.

At Pine Hill, which is situated about one mile fifty chains S. 40° E. from Wyalong Post Office, there is a belt of sedimentary rocks about ten chains wide, bounded on each side by diorite. The reef there was not well defined; but rich patches of quartz, one yielding as high as 35 oz. to the ton, were obtained from it. I was unable to get the returns from the claims on this hill.

Called Back Reef.—This line of reef is situated within an extension of the Wyalong granite, and is distant about three miles N.N.E. of Wyalong Post

Office. It was discovered nearly four years ago by Messrs. Hodge and Hunter, when on their return journey from the Nine-mile rush, and a short time after the discovery at Wyalong.

Gold-bearing quartz was found on the crown of the hill, near the southern end of the line. The strike of the main reef is N.E. and S.W., and its dip is slightly to the S.E.; but in places the reef is practically vertical.

A second reef lies about fifty feet to the east of the first; but little work has been done on it to prove whether it is of any value. The main reef has been traced for a distance of 1,200 feet, and at intervals along its course shafts have been put down on it, the deepest being 243 feet.

It is very remarkable that the country—rock, granite—is soft and decomposed even at that depth.

Water seems to be present in rather large quantity, and has retarded the development of this reef.

Some very good stone was taken from this reef in 1896, since when very little work has been done on it.

I am indebted to Mr. James Allen for the following information concerning the mines on the line of reef:—

Commencing on the north, the mines on this reef are the 9-acre Lease, Balaclava (G.L. 766), Lady Mary (formerly known as the North British Co. G.L. 769), Called Back United (G.L. 780), and No. 1 South. The reef has been worked principally in the Lady Mary and Called Back United Mines.

In the former the reef averages about two feet six inches in width, and the deepest shaft is 243 feet. About 160 tons of stone have been raised from the stopes between 125 and 170-foot levels, and have yielded 190 oz., or 1 oz. 4 dwts. per ton. The value of the stone ranged from 6 oz. to 6 dwts. per ton.

In the Called Back United Mine the reef varied in width from one inch to four feet, and averaged about two feet six inches. Fifty tons of stone, taken from some shallow shafts, yielded 10 dwt. per ton; and 215 tons from the stopes between 125 and 180-foot levels yielded 270 oz., or an average of 1 oz. 5 dwts. per ton.

From the Balaclava Mine only 48 tons of stone have been raised, yielding 50 oz., or 1 oz. 1 dwt. per ton.

No stone has yet been raised from the 9-acre Lease and No. 1 South.

Hiawatha.

While engaged on the geological examination of the Wyalong Gold-fields I paid several visits to Hiawatha, where prospecting operations were being vigorously carried on owing to the discovery of gold there in the early part of 1898. The site of the mining operations is about eight miles N.N.W. of Wyalong Township, on Portions 10 and 12, and the adjoining Crown lands of the Parish of Hiawatha, County Gipps.

Gold was first discovered on portion 12 by Messrs Conway and Ryan, and traced by them into the adjoining Crown lands. The discovery was made on Good Friday and reported on the following Monday.

All the reefs found at Hiawatha are in granite, which rock seems to occupy a large portion of the surrounding country, and would seem to be continuous with the Wyalong mass. All the reefs already found strike approximately E. and W., and dip to the north, and in these features differ from the Wyalong reefs, which have a general N. and S. trend.

The reefs are, on the whole, small and occasionally rich, but the gold contained in them is decidedly patchy in its distribution. In some cases, as at Molloy's Claim on Portion 10, rich prospects were obtained at the surface.

The best yield obtained from any of the Hiawatha reefs came from Crawley and Party's Claim on portion 10, and was 38 oz. 13 dwts. of gold from 9 tons of stone, or at the rate of 4 oz. 6 dwts. per ton. From other reefs yields as low as 3 or 4 dwts. per ton have been obtained. On the Prospector's Claim on Crown lands, a shaft 87 feet in depth has been sunk, and some driving has been done on a band of crushed rock, in which are occasionally large masses of quartz. The returns from this mine have been 8 tons for 11 oz. 17 dwts., or nearly 1½ oz. per ton, 2 tons treated by chlorination for 2 oz. per ton, 64 tons for 10 dwts. per ton, and 12 tons for 6½ dwts. per ton.

To the east of the Prospector's is Crampton's Claim (No. 1 East). The deepest shaft on this is 173 feet, vertical for 110 feet, and on the underlay for the remainder of the distance. The reef varies in size from 2 to 18 inches in thickness, averaging about 9 inches. The returns from this mine are 5 tons for 2 oz. per ton, and 16 tons for 5 dwts. per ton.

To the east of Crampton's Claim are two others known as "Early Morn," and "Nelson's." Ten tons of stone from the former yielded only 3 dwts. per ton, and 20 tons from the latter gave a similar yield.

Less than a quarter of a mile west of the Prospector's Claim, and on portion 12, is the "Blow." This is a large mass of quartz, which strikes east and west, and dips to the north. It has been sunk on to a depth of 60 feet, and 10 tons from it are said to have yielded 9½ dwts. to the ton, and another 10 tons 8½ dwts. per ton.

On Portion 10 Mr. D. Molloy, who holds an area of 5 acres, is the original finder of the gold. The reef in this ground varies in thickness from an inch or less to twenty inches, and dips at an angle of about 60° to the north. In the west end of the drive, at the 55-foot level, is a large white reef of poor quality, and much stained by black oxide of manganese. A little galena and iron pyrites are present in the reef. The returns from this mine have been 9 tons for 1 oz. 14 dwts. per ton, and 43 tons for 18½ dwts. per ton.

The reef in the claim adjoining the above on the west is small, and no stone has been raised from it, but specimens showing gold freely have recently been found.

In the claim to the east of Molloy's much sinking and driving was done, but nothing of any value was found.

A quarter of a mile E.N.E. of Molloy's Claim is Crowley's Claim. There two reefs were found, one about seven inches in thickness, on the footwall, consisting of hard white quartz, and containing very little gold; the other, on the hanging wall, about six inches in thickness, consisting of sandy quartz, is fairly rich. The reefs strike E. and W., and dip at about 80° to the north. The returns from this claim are—10 tons for 1 oz. per ton, and 9 tons for 4 oz. 6 dwts. per ton.

The other claims in this neighbourhood are Wilcoxson's and Ryan's. From the former 10 tons have been raised, and treated for a return of 16 dwts. per ton. A peculiar feature of this reef is the occurrence in it of a pale green opal. From Ryan's Claim 8 tons were treated for a return of 4 dwts. per ton.

Two other claims were being worked at the time of my visit; these are situated west of Crowley's, and near the road. On Fletcher's a shaft has been sunk to a depth of 124 feet, and a crosscut 18 feet long intersected the reef, which is about eight inches thick.

Sixteen and a half tons have been treated for a yield of 1 oz. 3 dwts. per ton. No stone has been raised from Dawson's Claim, where a reef six inches wide occurs.

[Map.]

Sydney: William Applegate Gullick, Government Printer.—1899.

NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.
No 6.

THE COPPER-MINING INDUSTRY

AND THE

Distribution of Copper Ores in New South Wales.

BY

J. E. CARNE, F.G.S.,
GEOLOGICAL SURVEYOR

1899.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

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Geological Survey Branch,
Department of Mines and Agriculture,

Sir, 13 June, 1899.

I have the honor to submit for publication Report No. 6 of the Mineral Resources Series, entitled "The Copper-mining Industry and the Distribution of Copper Ores in New South Wales," by Mr. J. E. Carne, F.G.S., Geological Surveyor.

The report deals, in considerable detail, with the history of copper-mining and copper-smelting in this Colony. All the known cupriferous deposits of New South Wales are described, and in the case of those which Mr. Carne has been unable to inspect personally, references are given to the previously published reports of other officers of the Department of Mines. A brief description is given, for purposes of comparison, of some of the principal copper-mines of other countries.

Useful information is also supplied in a compilation of the analyses of the various samples of fire-clays which have, from time to time, been received in the Department of Mines.

In view of the recent remarkable increase in the market value of copper, and the consequent impetus which has been given to this important branch of mining, Mr. Carne's carefully prepared monograph comes at a very opportune time, and it is hoped that it will be of considerable interest, as well as usefulness, to the mining community.

I may take this opportunity of pointing out that readers of this work can aid considerably in the preparation of future editions by informing me of the localities of any deposits not hitherto described.

I have the honor to be,

Sir,

Your obedient Servant,

EDWARD F. PITTMAN,

Government Geologist.

The Under Secretary for Mines and Agriculture.

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The Copper-mining Industry and the Distribution of Copper Ores in New South Wales.

INTRODUCTION.

THE copper-mining industry of New South Wales, after languishing for several years owing to the low price of copper and the consequent closing of some of the principal mines, entered upon a new era of prosperity about 1894 when the Great Cobar Mine was reopened under the advantages of improved and accelerated methods of ore reduction, and of rapid and constant transport afforded by railway communication with the sea-board.

The success of the undertaking has, moreover, been influenced to no small extent by realisation of the intrinsic worth of the valuable associated metals hitherto ignored, and augmented and confirmed by the steadily increasing value of copper—from £39 in 1893 to £75 in February, 1899.

This substantial advance has stimulated interest in copper properties both old and new, and awakened a desire to look further into mines long since closed under less favourable conditions.

The time being opportune an attempt is herein made to supply useful information for the benefit alike of the prospector, miner, and investor, by collecting and bringing up to date all the available information the Writer has been able to glean concerning the inception and progress of the copper-mining industry, and of the distribution of copper ores in New South Wales. Its object is threefold—concentrating the substance of early references and reports, recording present conditions, and registering known copper occurrences and localities. To this end public and private documents have been carefully noted, whilst the experience of many prominently connected with the industry, and the personal knowledge of the Writer and of his colleagues of the Department of Mines, have been placed under tribute.

It is believed that a useful purpose is served in thus presenting in convenient form the sum total of our knowledge of the subject, and in concentrating information previously scattered through numerous documents and publications, the earlier portions of which at least are hardly available to the general public.

Each of the older Colonies of Australasia has become noted for abundance of one or more essential elements of mineral wealth and prosperity; thus New South Wales for coal, silver, tin, and lead; Victoria, New Zealand, Queensland, and now the youngest Colony—West Australia—for gold; South Australia for copper; and Tasmania for tin.

In copper New South Wales ranks second to South Australia as regards the total value of production to date, whilst Tasmania, thanks to Mount Lyell, assumed the premier position in the annual output in 1897; the mother Colony ranking second. The relative figures for each of the Colonies are as follows:—

Colony.	* Production for 1897.	Total Production to end of 1897.
South Australia	£242,917	£21,280,889
New South Wales	283,174	4,351,343
Queensland	12,645	2,020,761
Tasmania	323,650	491,876
Victoria	....	206,395
West Australia	1,033	167,849
New Zealand	2	17,868
	Total	£28,536,981

The production of New South Wales for 1898 according to the Customs returns, of ingots, matte, and ore = 5,832 tons = amounts to the value of £280,887.

In bringing the chequered history of the local copper-mining industry up to date, advantage has been taken of the opportunities afforded by consideration of individual enterprises, to contrast past and present difficulties besetting them, and the methods and processes experience and altering conditions have suggested and enforced.

Copper-mining, no less than that of the nobler metals, has had its "boom" times and its reactionary depressions, the causes of which in some instances were not far to seek; notably the fictitious advance in value in 1888 consequent on the futile attempt of a French Société des Metaux to "corner" the market, which entailed loss and disappointment through speculative investment and attempted exploitation of unworkable deposits. Slowly, but surely, the industry has recovered from the inevitable fall in values following the Society's failure and the over-production it had encouraged. In the absence of any recognisable evidences of adventitious stimulants at the present time, it appears safe to conjecture that the steadily-maintained advance in the market value of copper during 1898, notwithstanding the rather disconcerting jump to £75 per ton in February, 1899, attributed to a similar attempt to control the market, is the natural outcome of increased and healthy demand; an opinion evidently entertained by capitalists who are devoting considerable attention to copper properties. According to the circular of Messrs. H. R. Merton & Co., of London,† the deliveries, which are defined as "Sales and Approximate Consumption," for three years past have exceeded the supplies or visible stock in Europe. In 1896-97 the excess was 13,821 tons; in 1897-98 it was 2,561 tons; and in 1898-99 it was 3,731 tons. The visible supply in Europe on 31st January, 1899, was, therefore, less than on the corresponding date in 1896 by 20,113 tons.

Each important productive deposit has received independent historic notice embracing all available particulars of discovery, size, nature of the ores, extent of development and output,†† and the methods of treatment adopted. In each case where the mine is still working, these data have been brought up to the present chiefly from personal inspection by the Writer. The individual descriptions may in some instances appear prolix, but experience has proved that even apparently trivial details have a value and are eagerly sought by those desirous of information on which to base a decision.

* T. A. Coghlan, The Seven Colonies of Australasia, 1897-8, p. 524.

† Engineering and Mining Journal, 1899, LXVII, No. 10, pp. 288-289.

†† In some instances the outputs may be only approximate as they are dependent entirely upon the courtesy or willingness of the owners; returns not being compulsory under the New South Wales Mining Act. The authorities, however, are given.

In noting the occurrence of copper no restriction has been adopted in the Register, but with a desire of imparting knowledge of the universality of the distribution of the ores of this metal throughout the Colony, its scope has been widened to embrace all cupriferous localities irrespective of abundance or richness; the individual references, however, contain all that is known of each deposit.

Brief descriptive notices of some of the principal copper lodes of the world have also been introduced for comparison and instruction, as very erroneous impressions frequently prevail concerning them.

In making the Register as complete as possible in the hope of rendering it serviceable to prospectors—otherwise many of the entries would hardly be justified—advantage has been taken of sources of information of which corroborative evidence is not always available, such as the Departmental Assay Register, which depends for the genuineness of its localities upon the good faith of those desirous of having assays made.

To the valuable Office Register of mineral localities compiled by Mr. O. Trickett, L.S., of the Geological Survey, the Writer was indebted for his initial list.

The Annual Reports of the Under Secretaries for Mines since the inauguration of the Department in 1874, and those of the Wardens, Mining Registrars, and Inspectors of Mines, and the geological reports and publications of the officers of the Geological Survey, have been largely availed of and placed under contribution.

To the Clerk of Assembly and the Parliamentary Librarian the Writer is indebted for access to Legislative Publications and Proceedings dating back to the early twenties. To Mr. Leonard Dodds, Manager of the Great Cobar and Girilambone Copper Mining Companies, and Mr. S. L. Bensusan special thanks are due for assistance most generously given.

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To the splendid work on Modern Copper Smelting by Dr. E. D. Peters, junr., the Writer is indebted for much valuable information, which has been freely used in this work.

A bibliography has not been attempted, the usual foot-note references to authorities being preferred as more convenient to readers, and just to authors.

Historical.

Copper-mining probably began in New South Wales between 1844 and 1845. In the latter year Mr. James Ranken, of Bathurst, visited mines at work at Copper Hill, near Molong, and at Lipscombe Pools Creek, fourteen miles from Canowindra; the late Mr. W. M. Rothery, on whose station the latter is situated, confirmed this date, and afforded particulars of the work performed. In 1847 Mr. Ranken also visited the operations in progress on the Summerhill Estate, near Rockley. In 1848 the prospectus of a proposed company to work the lode at the latter was published in the *Bathurst Advocate* of the 30th December of that year. Probably this is the earliest public announcement of a local copper-mining enterprise, if, indeed, it be not the earliest metalliferous mining company formed in the Colony, for it is more than probable that copper was the first metal mined in New South Wales.

The object of the Bathurst Copper-mining Company was set forth in the prospectus quoted. "Copper ore having been discovered on the estate of John Findlater Clements, Esq., known as Summerhill, situated on Campbell's River about twenty-five miles from Bathurst, thirty individuals agreed to subscribe £30 each, and formed themselves into an association for the purpose of opening a mine on that estate, with the ultimate view of establishing a public company, should their operations turn out favourably in the meanwhile."

After sinking a shaft, and other prospecting, the report of an experienced miner—Mr. John Whitford—was obtained, to the effect that a lode had been disclosed which, in his opinion, could be worked with considerable profit. The right of mining over the estate of 1,500 acres was secured for twenty-one years, with the option of renewal for a like period.

Materials requisite for erecting smelting works were reported to occur on the ground. Advantage was doubtless to be taken of the fire-resisting qualities of the steatitic rocks of the serpentine belt of the locality.

In 1853 a Select Committee of the Legislative Council reported on a Bill to incorporate the company, whose object was then widened to "open and carry on mines and mining operations at Summerhill, and to obtain copper and other ores, and to dispose of same, and to smelt and refine all or any of the said ores on the land opened or elsewhere."

The first copper and lead ores mined in Australasia (in South Australia and New Zealand) were shipped to England for treatment. As early as 1846 the *Mining Journal** advocated the wiser plan of utilising the coal resources of Newcastle in reducing the metals from their ores, instead of shipping the latter abroad, a course which was shortly adopted, for in the same journal† mention is made of the production of the first refined copper at the "Newcastle Copper-smelting Works" in this Colony (from South Australian ores). Though mines were at work in New South Wales, and it is believed that two or more smelting works were connected therewith, there is no official record of export at the Customs Office prior to 1858, when 58 tons were entered.

The earliest official record of copper-mining is that contained in a dispatch from Governor Sir Charles Fitzroy to the Right Honorable Earl Grey, dated 1st March, 1849,‡ which as an epitome of the mining of that date is worthy of insertion *in extenso*. In it the Governor urged the expediency of a geological and mineralogical survey of the Colony, as the subject had been engaging attention for several years in consequence of the great success attending the opening of some of the copper mines of South Australia, in which Colony the first copper lode had been discovered and opened in 1842. He further added that—

"Copper mines are already in operation in the neighbourhood of Yass [Good Hope ?—J.E.C.] and at Molong [Copper Hill.—J.E.C.], near Wellington Valley.

"The success which has attended the opening of these mines has as yet only been partial, but experiment has not yet proceeded far enough to test with any certainty their ultimate productiveness. It is also contemplated, I understand, to open mines in the neighbourhood of Carcoar [Coombing ?—

* Vol. XVI, p. 486. † Vol. XXII, p. 66, 1852.
‡ Votes and Proceedings of the Legislative Council for 1849.

J.E.C.], in the county of Bathurst, and at Summerhill, in the same county, where strong indications of the existence of lodes of sufficient richness to justify their being worked have for some time been know to exist.

"A lead mine was opened during last year in the neighbourhood of Yass [Woolgarlo?—J.E.C.], but has been abandoned in consequence of its not being proved sufficiently productive to defray expenses of working it.

"An iron mine was also recently opened in the neighbourhood of Berrima" [the Fitzroy Mine, Nattai.—J.E.C.]. It may not be superfluous to add that all the mines which have as yet been opened are on lands which have been alienated from the Crown without any reservation of the mineral rights."

The Governor concluded by recommending that a competent geologist be sent out. The position was subsequently offered to Mr. Beete Jukes who declined it; afterwards Mr. Bristowe was selected but did not take up the work for family reasons. Later, Mr. S. Stutchbury was appointed to the position of the first Government Geological Surveyor, which he occupied until 1855, when he resigned on account of failing health.

In 1803, Mr. A. W. H. Humphery was appointed as Mineralogist to the Territories of New South Wales. His arrival in March was noted, but there is no record of any reports having been furnished by him.*

In 1851, Mr. J. R. Hardy, Commissioner of Crown Lands for the gold district, writing to the Governor, on 12th June, from Summerhill Creek near Orange, reported that several Cornish miners had applied to him to be allowed to work copper ore on the same terms as gold, namely, on payment of 30s. per man monthly†. Mr. Hardy recommended that the request be granted if within the province of the Government, as it was very desirable that every valuable article of export should be developed, and that it would give back loading to teams bringing supplies to the gold-fields, thereby lessening cost of transit.

On the 24th June the Governor invited the attention of the Executive Council to the application. The latter, however, was of opinion that "there was no such analogy between digging for gold and working copper mines as to render practicable the application of the same code of regulations to both." It, however, recommended "that until proper regulations were established for the working of metals other than gold, that any Crown lands containing such should be surveyed and offered for sale as mineral lands at an upset price sufficient to cover their proper value."

The difficulty of ascertaining the latter doubtless caused the abandonment of this idea of dealing with metalliferous lands, for no provision was made in the first Mining Act, issued in 1852, which was confined to gold-mining only. Nor did that of 1855 which repealed the previous Act and substituted the "miners' right" for the license to mine, and also provided for the issue of gold-mining and business leases, make any provision for minerals other than gold. Neither did the Act of 1857 remedy this defect.

In the Crown Lands Act of 1861 provision was first made for mineral leases; prior to this it would appear that copper-mining was entirely confined to private lands or was unprotected by specific title.

The first copper lease registered in the Departmental records, so far as can be ascertained, was in 1864, being Portion 448, Parish Baring, County Westmoreland, taken up by H. Donnelly.

In 1851 the first geological examination of the then known copper lodes of the Colony was begun, for in the official records of that year are embodied reports by Mr. S. Stutchbury, Government Geological Surveyor, and the

* Lord Hobart to Governor King, 24th February, 1803, Hist. Records of N. S. Wales, 1803–1805, p. 47.

† Probably at Carangara, near Byng, afterwards known as the Cornish Settlement.

Rev. W. B. Clarke, who was also engaged by the Executive Council to make geological examinations, chiefly, however, in connection with gold; but, as was characteristic of Mr. Clarke's work, little escaped his keen observation, hence references to copper localities are frequent in his reports.

Apparently Mr. Stutchbury's first duty on arrival in the Colony was the systematic examination of the copper mines in operation, and of all known cupriferous localities. Under the names of the mines in the descriptive record of this paper will be found details of his report on them at that early date. In these introductory notes a short itinerary in connection therewith alone will be given.

It is significant that as early as the 12th April, 1851, inspired doubtless by phenomena observed in his travels, he took the opportunity of chronicling his opinion "that the large masses of iron ore found in veins and on mountain tops will, in some way or other, be found to be connected with copper or other metallic lodes." Probably the allusion was to gossany outcrops destitute of any surface traces of copper ores which might naturally be expected to mark the decomposition of cupriferous pyrites. In another portion of this work this interesting subject will receive further attention.

In 1851 Mr. Stutchbury reported on the Summerhill, Coombing, Cornish Settlement (Carangara), and other mines, and on deposits then unopened.*

In the same year Mr. (afterwards Sir Thomas) Mitchell, Surveyor-General, in a report on the gold-fields of the Bathurst District, mentioned copper mines at Kyong (probably Guyong, near Carangara) and at Copper Hill, near Molong, but gave no particulars.

In September, 1851, the Rev. W. B. Clarke recorded the presence of copper ores in "more or less abundance" a few miles to the westward of Inverary Quarry in the Marulan District, also their occurrence in the neighbourhood of Boro, where the Mulloon Copper Mine was afterwards opened about 1872.

In February, 1852, he noted the presence of copper and lead ores at Quidong, near the Snowy River, close to the Victorian border, and anticipated a profitable mining field. In 1868 the prospectus of the "Belmore Freehold Silver and Lead Mining Company," Quidong, was announced in the press. Subsequently prospecting operations were begun both for the silver-lead and the copper ores, and a furnace and battery erected, but apparently little ore was obtained, as the furnace betrays but slight evidence of use.

The approximate chronological order of opening of the best-known copper mines in the Colony is as follows:—

	Mine.	Mining District.	Division.
†1845	Copper Hill	Bathurst	Molong.
1845	Belubula	,,	Canowindra.
1846	Summerhill	,,	Rockley.
†1847	,,	,,	,,
1848	Good Hope	Southern	Yass.
†1849	,,	,,	,,
†1850	Coombing Park	Bathurst	Carcoar.
†1850	Carangera	,,	Orange.
†1851 to 1865	Cadia	,,	,,
	Icely	,,	,,
	Ophir (1852)	,,	,,
	Britannia	,,	,,
	Belmore	,,	,,
	Moonta	,,	,,
	Nelson	,,	,,
	Geurophian	,,	,,

* Mr. Stutchbury's reports are published in Votes and Proceedings of the Legislative Council under the years mentioned, and may be seen at the Public Library.

† Reverberatory furnaces erected.

	Mine.	Mining District.	Division.
*1865	Currowong	Southern	Goulburn.
1867	Belmore	Bathurst	Cowra.
*1868	,,	Tumut and Adelong	Delegate and Bombala.
*§1868	Goodrich	Tambaroora and Turon	Ironbarks.
*†‡1869	Great Cobar	Cobar	Cobar.
§*1872	Essington	Bathurst	Rockley.
1873	,,	,,	,,
*1873	Peelwood	,,	Tuena.
1873	,,	,,	,,
*1873	Wiseman's Creek	,,	Rockley.
*1873	Cow Flat	,,	,,
*1873	Milburn Creek	,,	Trunkey.
*1873	Frogmoor	Southern	Boorowa.
*1874	Belara	Mudgee	Wellington.
1875	Belmore	Bathurst	Rockley.
*§1875	Apsley	,,	,,
†1875	Armstrong	,,	Bathurst.
*1874	Snowball	Tumut and Adelong	Adelong.
1875	,,	,, ,,	,,
*†1876	Burraga	Bathurst	Burraga.
*†1877	,,	,,	,,
§†1877	Burley Jackey	,,	Cowra.
*†1878	New Mount Hope	Cobar	Mount Hope.
*†1878	Great Central	,,	,,
*‡†1879	Nymagee	,,	Nymagee.
*†‡1880	,,	,,	,,
‡*†1880	Girilambone	,,	Nyngan.
*†‡1881	Annandale	Bathurst	Blayney.
*†‡1882	Captain's Flat	Southern	Captain's Flat.
§*1895	Cornish	Peel and Uralla	Barraba.
1895	Mayfield	Southern	Boorowa.

Copper.

Copper was probably the earliest of the metals converted to human use; certainly it is the first of which relics have been discovered amongst the primitive implements of prehistoric man, and has, indeed, furnished evidence of his intellectual progression by the advance it marks in material adaptation to his needs. With the abundant celts or stone implements of North America —where native copper abounded at Lake Superior—occur similar forms in metallic copper. Probably first by hammering, and subsequently by melting, the native metal was shaped according to the knowledge of our ancestors. Later, by the addition of lead, zinc, or tin, which may first have been naturally associated with copper ores, was the harder bronze alloy obtained. The far more infusible and valuable iron—which in its native state is a rarity in nature—was still later smelted from its ores. The intellectual and industrial progress of prehistoric man has, by means of his weapons and implements, been divided by archæologists into—

(*a*) Palæolithic or Ancient Stone Age—Roughly chipped and unpolished flints and chips.
(*b*) Neolithic or Newer Stone Age—Smoothed and polished flints and chips.
(*c*) Copper and Bronze Age.
(*d*) Iron Age.

The composition of a prehistoric bronze from Ireland is given by Professor Roberts-Austen‖ as—copper, 83·5; tin, 5·15; lead, 8·3; iron, 3·0.

* Reverberatory furnaces erected. † Working. ‡ Blast furnaces adopted or in course of erection. § Re-opening.

‖ An Introduction to the Study of Metallurgy. 3rd ed., 1894, p. 105.

Copper, of all metals, most readily betrays its presence in Nature by the remarkably attractive colouring assumed by some of the ores resulting from its decomposition, such as the carbonates, silicates, and oxychlorides. The beautiful sapphire-blue azurite, the bright and dark green malachite, the turquoise-blue chrysocolla, the dark green atacamite, and the pellucid blue sulphate from solution, are specially distinctive. Mere traces of some of these minerals characteristically colour large outcrops of rock, or the dry beds and sides of channels through which cupriferous waters have intermittent flow. These superficial colourings may frequently be delusive, and entail endless labour and disappointment on the uninitiated, especially in those instances resulting from decomposition or alteration of small particles of native copper, or one of its sulphide compounds, occurring probably as idiogenetic, or original constituents, of some intrusive rock, as in the Wellington and Carcoar Districts.

Usually one of the most favourable surface indications of an extensive copper lode is abundant gossany or cellular iron oxide and quartz, stained with carbonates of copper, commonly described by old copper-miners as a "good iron hat" or "an iron saddle riding a good horse." Such an outcrop affords presumptive evidence of extensive deposits of sulphides below the zone of oxidation or water-level. But surface indications cannot be relied on as infallible guides to conditions below. The Great Cobar, Nymagee, New Mount Hope, and Burraga Mines were instances of the unreliability of any one set of conditions for all occurrences; Cobar, in particular, afforded little surface evidence of the immense bodies of payable ore beneath. The reverse also frequently holds good, large and promising outcrops capping lean and unprofitable deposits. Copper Hill, near Molong, and possibly Cow Flat Mines, may be cited as instances of failure to realise the fair promise of the outcrops so far as tested.

Though the presence of copper is usually recognisable in a gossany outcrop forming the back of a copper-bearing lode, yet its absence must not be inferred from lack of the usual indications, for notable instances are not wanting of such a deficiency. According to Dr. Peters, junr.,* the famous Montana lode, which at the present day, perhaps, is furnishing the largest amount of copper from any single deposit in the world, down to levels averaging about 250 feet from the surface carried comparatively no copper, and was worked solely for the silver it contained;† it had, in fact, become a low-grade silver deposit. At the level mentioned, a rich zone of copper ore was struck between the argentiferous, yellow, quartzose cap and the leaner copper ores below. The Anaconda Mine was, perhaps, the only exception, the rich zone being met under 200 feet from the surface. The cause of the enrichment was, doubtless, the leaching and removal of the copper from the higher levels, and reprecipitation and concentration below; the line of demarcation between the impoverished and enriched zones being sudden and distinct.

The famous Burra and Moonta Mines of South Australia also furnish evidence which counsels caution in condemning a ferruginous deposit betraying little surface indication of permanent deposits beneath.

At the Burra Mine, according to Mr. H. Y. L. Brown, Government Geologist,‡ there was no appearance of defined ore-bodies above the 180-foot level, the carbonates occurring very irregularly as nodules and investing cavities and fissures, but below the 180-foot level regular lodes were met containing very rich ores—malachite, cuprite, and grey ore.

* Modern Copper Smelting. 5th ed., 1892, p. 16. † In the 7th edition the figures are 40 to 300 feet.
‡ Record of South Australian Mines.

In the Moonta Mine, according to the same authority, between a very thin superficial coating of malachite and atacamite only a few inches thick, and the 50 or 60 foot level, no further ore was met, and, as a rule, not even a stain indicated the rich oxides and malleable copper just beneath, which were succeeded by black and grey sulphides.

In the Great Blayney or Annandale Mine of this Colony, beyond a mere trace, in a thin quartz vein, no copper ore was met above the 90-foot level, though some 2,000 tons of iron ore were removed from the back of the lode for iron-smelting at Lithgow.

Going further afield for examples, according to R. Hunt, F.R.S.,* in Cornwall no copper ore of any value was raised until the 180-foot or 240-foot levels were reached, and that the great mine of Przibram in Bohemia had to be sunk 120 to 180 feet before it became productive.

The instances quoted are sufficient to demonstrate the wisdom of continuing sinking in the cap of a copper lode, until the water-level and the yellow sulphide zone are reached. The rich secondary ores, such as copper glance (grey ore) and bornite, resulting from the leaching of the higher levels and re-deposition, are usually found concentrated just about water-level, and above the ordinary chalcopyrite (yellow ore). When the latter is reached little permanent alteration for the better can be anticipated, but rather the reverse; the general experience being that depreciation waits on depth.

The cause of the occasional enrichment of the lower levels and the poverty of the cap is the greater solubility of the copper salts resulting from the decomposition of cupriferous pyrites, than those of the associated iron sulphide, which meanwhile are converted chiefly into insoluble oxides. The copper salts are thus removed by percolating waters, and carried to lower levels where precipitation in more concentrated form ensues.

An interesting instance of the relative solubility of copper, zinc, and iron is afforded in the accompanying analyses of samples of mine water from the Currowong Mine, near Lake George, the proportions of the several metallic salts manifest their differing solubility:—

	† Water from Working Shaft.	Water from Old Shaft.	Water from Currowong Creek.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
Sulphate of Copper	1·12	17·67	6·42
,, of Zinc	16·98	53·54	·7·20
,, of Iron	0·43	1·42	0·98

The sulphur compounds of copper being less stable under the chemical reactions set up by ordinary atmospheric conditions in an outcrop, than those of the commonly associated metals, such as iron, lead, silver, and free gold, are frequently almost entirely removed, and redeposited at lower levels comparatively freed from the latter, which remain to enrich the leached gossan.

In the artificially-stimulated reactions of the roasting furnace, however, the reverse holds good as regards the commonest associate—iron sulphide. It is possible to remove the latter as a loose pulverulent oxide, whilst the intimately mixed copper sulphide not only remains scarcely altered, but melts and retreats to the centre of the ore lump through the porous iron oxide, a movement taken advantage of in "kernel roasting."

* British Mining, 1884, p. 505. † Ann. Rept. Dept. Mines for 1890, p. 59.

As Dr. Peters points out*, the metallurgical processes for obtaining copper from its ores are based upon its strong affinity for sulphur, wherein it exceeds every other metal. Silver frequently accompanies the leached and redeposited copper from the upper levels of lodes. Dr. Peters gives two very interesting instances of this.† Just below the oxidised cap of a portion of the Rio Tinto deposits (Spain) was a soft, greyish, earthy deposit from one to six inches thick, resting on the scarcely altered pyrites, which contained from 50 to 150 oz. of silver per ton, whilst the original pyrites contained about 1 oz. or less, per ton.

At one portion of the Mt. Lyell (Tasmania) deposit of pyrites, which averaged about 4½ to 5 per cent. of copper, with 3 dwt. of gold and 3 oz. of silver per ton, a remarkable chute of gossan descended on the footwall to the 200-ft. level. It contained nearly the same amount of gold as the original pyrites from which it was derived, but neither copper nor silver, the latter having been leached out and redeposited on the footwall under the lower border of the gossan in a series of extensive and irregular pockets. The first 50 tons extracted averaged close to 2,000 oz. of silver per ton, and 21 per cent. of copper.

In arid tracts where denudation has not been extensive, and where climatic conditions have assisted decomposition, as at Cobar and Broken Hill, oxidation extends to considerable depths, from 250 to 400 feet in the instances mentioned; though the vertical level of alteration is never uniform, being determined by the nature of the different portions of the lodes, and the occurrence of open fissures and caverns.

One of the most striking examples of a large outcrop, and of the effects of oxidation, leaching, and partial removal, was furnished by the famous Broken Hill silver-lead lode. Its bold, rugged outcrop of manganiferous iron oxide, upwards of 300 feet wide in places, formed a conspicuous feature in the landscape prior to the introduction of the open-cut system of extraction. From the oxidised cap of this giant lode the zinc sulphide, which is causing such metallurgical trouble at lower levels, was almost completely removed, leaving a kindly ferruginous carbonate of lead under the iron cover.

The potential action of circulating waters above and below permanent water-level is distinctly opposite; in the former it oxidises and dissolves, in the latter protects from oxidation, and tends to deposit rather than dissolve.

Uses of Copper.

The qualities and uses of copper are so well known that repetition is unnecessary. Reference might, however, be made to the large part it is destined to take in the increasing application of electricity to the industrial arts and sciences, owing to its great conductivity (931, silver being 1,000). The practical potentialities of electrical energy appear almost boundless, and all things point to its rapid conversion to wider and ever-augmenting demands of human progress. Herein lies one of the most hopeful auguries of the copper industry. At the same time, it must be borne in mind that aluminium is likely to prove a dangerous rival for electrical purposes, especially if a high price be maintained for copper. The cost of aluminium has been rapidly reduced during the past few years, until at the present time it is only double the cost of copper; whilst, bulk for bulk, copper is 3·3 times heavier

* Modern Copper Smelting 9th ed., p. 5, 1898.
† *Op. cit.*, p. 11.

BROKEN HILL.

(Original outcrop of lode at south end of Block 11.)

than aluminium. Pure aluminium* has a conductivity of 63 to 64 %, or 630 to 640 compared with the silver standard of 1,000. Several hundred miles of aluminium wire for movable telephone and telegraphic work are in use. Its extreme lightness renders it most suitable for field military telephones and telegraphs.† A contract has been let to supply 150,000 lb. of aluminium wire to convey power from the Shoqualme Falls, to Tecoma, Washington; the metal to be alloyed with 1½ per cent. of pure copper. In connection with this subject it is interesting to note the recent discovery of the most important commercial ore of aluminium—bauxite—in New South Wales. For electrical purposes copper must be practically free from impurities, as such tend to diminish its conductivity. Lake Superior copper—prepared from the native metal—enjoys the distinction of being equal, or almost so, to copper prepared by electrolysis, owing to its purity.

Commercial Copper Ores.

Copper occurs in Nature in a variety of combinations with other elements, but those of commercial importance are comparatively few, and only such will be considered here.

Native Copper—Specific gravity, 8 to 8·9, when pure and solid.—Native copper is common in New South Wales wherever copper ores occur, but in no instance has it been discovered in appreciable quantities. In the oxidised zone of the Great Cobar, Girilambone, Blayney, Peelwood, and other mines, it occurred in small irregular masses, crystalline, arborescent, and leafy forms. In the Broken Hill lode very beautifully crystallised aggregates of native copper and cuprite occurred above water-level, where also a new combination—iodide of copper—was discovered by Mr. C. W. Marsh, after whom Professor Liversidge proposed to name it "Marshite."‡

Since the discovery of the new mineral "Marshite" at Broken Hill iodine has been detected in cuprite and malachite from New South Wales, unfortunately the exact locality of its occurrence is not yet known, notwithstanding a number of tests recently made of cuprite from the principal mines. This latest discovery is of commercial importance, as the iodine is in payable proportion.

In a private letter received by Mr. G. W. Card, A.R.S.M., Curator of the Mining Museum, from Mr. Arthur Dieseldorf, M.E., of Freiberg, Germany, the latter states, "Amongst a lot of New South Wales minerals which came to my hand lately as a present from a New South Wales gentleman, I found a piece of cuprite decomposed to a large extent to Malachite, which showed tiny crystals of Malachite. An analysis shows both to be containing Iodine in appreciable quantities." Now, my friend is unable to tell the origin of the piece, also the locality it comes from.

In a subsequent letter dated 4th February, 1899, Mr. Dieseldorf further alludes to the subject:—"Regarding Iodine, I can now say, that there is no silver present in the sample I send you, being the one I analysed. The results are:—In the Malachite I find Co_2, Cl, I, and Cu (no Ag,§ therefore, it is a mixture of Atacamite and Malachite in which the I replaces a part of the Cl. In the cuprite itself I find also no Ag, but Cu with O, and also Cl plus I. In fact the cuprite must be smelted with carbonate of potassium to give up all the iodine." . . . . . .

"The contents of the ore are up to 0·1 per cent. (average of three analyses)."

* Mineral Industry, VI, 1898, p. 39. † Aust. Mining Standard, 13th April, 1899.
‡ Journ. R. Soc. N.S. Wales, 1892, XXVI., p. 328.
§ Cobalt oxide, Chlorine, Iodine and Copper (no silver).—J.E.C.

At Reedy Spring, near Molong, on the Gamboola Estate, one of the largest blocks of native copper—1 cwt.—found in the Colony, was discovered, and exhibited in the London Exhibition of 1851. A similar block from the same locality, weighing three-quarters of a hundredweight is now at the station homestead. Mr. Stutchbury recorded the presence of native copper in porphyry in this locality in 1852.

It is interesting to note that at Lake Superior, U.S., masses of native copper weighing several hundred tons were found, the largest, according to C. Le Neve Foster* weighing nearly 600 tons. These immense masses proved anything but profitable discoveries owing to the difficulty of extraction, having literally to be sawn into blocks for removal.

In the andesitic and epidotic rocks of Wellington, Cowra, and Carcoar Districts, small, possibly idiogenetic grains, and thin secondary vein-lets of native copper are present, which, owing to decomposition at the outcrops, frequently very deceptively stain large areas of rock superficially.

The presence of minute particles of native copper in the tuffaceous shales of the Narrabeen Series (Triassic) overlying the Sydney Permo-Carboniferous Coal Basin, will be found fully described in another section of this work. It is also found in a basalt at Kiama, which is regarded by Professor David as one of the probable sources of the volcanic particles in the cupriferous shales.†

Cuprite (Red Oxide of Copper) Cu_2O. Specific gravity, 5·8–6·1. (Composition—copper, 88·8; oxygen, 11·2 = 100).—This is the richest ore of copper, and is found in the upper portions of lodes, frequently forming a coating on native copper as a result of decomposition. Though rarely persistent in lodes, and comparatively scarce when compared with lower-grade combinations, it is yet frequently of considerable commercial importance. In the Great Cobar lode it occurred in massive bunches of great purity near the surface. At Girilambone it still forms an important source of the metal in the South lode, where it occurs as "carbonas" or isolated nodules, which probably represent altered masses of native copper. In most of the copper-mines of the Colony it was present, but rarely, if ever, in quantity approaching the Cobar occurrence.

Melaconite (Black Oxide of Copper) CuO_2. (Composition—copper, 79·8; oxygen, 20·2 = 100). Specific gravity, 6·2 (when solid).—This, the second richest ore of copper, though of common occurrence, has not yet been found in extensive deposits in New South Wales. It usually occurs strongest in the transitional zone, between the thoroughly oxidised ores and the yellow sulphide below water-level, which owes its enrichment chiefly to the partial alteration of the latter into black oxide. Unfortunately, in this state it frequently forms an incoherent powder very difficult to save in mining and dressing, hence a good deal of actual loss occurs.

Malachite (Green Carbonate of Copper) $CuCO_3 + Cu(OH_2)$ (Peters). Specific gravity, 3·7 to 4. (Composition—cuprous oxide, 71·9; carbonic acid, 19·9; water, 8·2 = 100).—Malachite is a valuable ore of copper, and one of the most common in the oxidised zone; hence it is familiar to miners and necessitating brief notice only. In all the principal mines of the Colony, with the sister carbonate—azurite—it furnished considerable supplies of direct smelting ore. At Cobar it occasionally occurred fairly massive, but

* Text-book of Ore and Stone Mining, 1894, p. 86.

† Rept. Austr. Assoc. Adv. Sci., 1881, I, p. 289.

not sufficiently so for ornamental purposes. At New Mount Hope it occurred in rather earthy form, and as a "stockwork" of minute interlacing veins, an interesting feature of which is the secondary origin of some of the malachite veins which cross and intrude the azurite. Beautiful velvet and moss-like crystalline aggregates (sometimes stellate) frequently lined fissures and cavities in both mines. The Cobar carbonate ores are practically exhausted in the present workings, but at Girilambone, New Mount Hope, and the Central, considerable quantities of low-grade carbonates and oxides still await an economic and efficient treatment, probably other than smelting, in consequence of the excess of silica, and the absence of solid sulphides.

Azurite (Blue Carbonate of Copper) $2CuCO_3 + Cu(OH_2)$. Specific gravity, 3·7 to 3·8. (Composition—cuprous oxide, 69·2; carbonic acid, 25·6; water, 5·2 = 100).—Azurite occurs almost invariably associated with malachite, but in lesser quantities, and is, therefore, common in the upper levels of copper lodes. Very beautiful radiate crystalline aggregates were obtained in the New Mount Hope and Girilambone lodes, and almost equally as fine crystals from the Peelwood and Broken Hill lodes.

Chalcocite (Copper Glance, Grey Sulphide of Copper) Cu_2S, locally known as "grey ore" amongst miners. Specific gravity, 5·8. (Composition—copper, 79·7; sulphur, 20·3 = 100).—One of the most important ores of copper, usually resulting from redeposition of copper-salts leached from the upper levels. It occurs in most of the local copper lodes. At Cobar it formed massive bunches. At the Bingara mines, and Payne's Reedy Creek Mine, Bumbery, some of the most characteristic examples of this ore have been obtained; usually, however, it is massive and destitute of typical structure and lustre.

Bornite or *Erubescite* (Variegated Copper Ore) $3Cu_2S.$, Fe_2S_3. Specific gravity, 4·5 to 5·5. (Composition—copper, 55·58; iron, 16·36; sulphur, 28·06=100.)—A rich ore of copper, also probably derived from the redeposition of ores leached from higher levels. It is remarkable for rich colouring, (to quote Dr. Peters) from "golden yellow to deepest indigo, and from brilliant green to royal purple," which the freshly-broken purplish-brown mineral assumes on exposure to the air. It occurs sparingly in a number of localities in the Colony. In the Burley Jacky Mine, near Woodstock, the only important deposit was mined, upwards of £40,000 worth of bornite being raised from one chute, averaging 30 per cent. of copper. At the Hampden Mine, a new discovery between Mount Victoria and Jenolan Caves, bornite also occurs, but the quantity is doubtful.

Chalcopyrite (Yellow Sulphide of Copper, Copper Pyrites) $Cu_2S.$, Fe_2S_3. Specific gravity, 4·1 to 4·5. (Composition—copper, 34·4; iron, 30·5; sulphur, 35·1=100).—Copper pyrites is the most widely distributed, and in view of its persistence in depth, the most important ore of copper. The lower extension of all copper lodes almost invariably owe their value to chalcopyrite; and conversely nearly all the ores in the surface zone have originally resulted from its decomposition. Usually it occurs associated with iron sulphide—pyrite—as a mechanical mixture; in the most important deposits the iron pyrite constitutes the chief lode mineral, and generally carries small proportions of gold and silver, which are recoverable under metallurgical treatment. In the descriptive notes on Working Mines, particularly in connection with smelting and concentration, where it occurs sparingly and independently disseminated through the gangue, this important ore will be fully discussed.

ABANDONED MINES.

An endeavour has been made to ascertain the fullest possible information obtainable under the circumstances on the nature of the ores, and the extent of development of the early-opened copper mines of the Colony, the sites of many of which are marked only by old mullock heaps, slag dumps, and ruins of furnaces. The value of these records of the dead past may not at first glance be apparent, but viewed in the light of the successful reopening and working of mines at the present day, which in the past had a fluctuating existence, neither the time nor the effort is in vain.

In the early days of copper mining and smelting in New South Wales lean ores were either disregarded in mining or discarded in sorting, only such as would pay to smelt direct at the mines, or cover the higher additional cost of carriage and smelting at some central works, being handled. The early miners had further to contend with enormous initial outlay attendant upon long carriage by teams over bad roads (over 300 miles in the case of Cobar, for which as high as £42 per ton was paid) to the nearest railway; conservation of water, in some instances in arid country destitute of natural drainage channels; in fact in almost every essential for development an outlay was incurred altogether disproportionate to the cost of similar requirements in these latter days of extended railways and cheaper freights and fuel.

The successful working of the far Western mines under these abnormal handicaps for a number of years is eloquent testimony to the richness of the ores near the surface, as well as to those of mines nearer the seaboard, opened in earlier days under rather more favourable conditions as regards distance of carriage and of water supply.

Exhaustion of these richer oxidised supplies, and encountering with depth the more permanent but greatly poorer sulphides below the water-level, in many cases compelled abandonment, in some instances abruptly when the position was aggravated by a sudden drop in the market value of copper.

It may be approximately stated that, even under existing local conditions, a return of less than £45 per ton to the producer will not afford a margin for profitable working, except, perhaps, in the case of ores capable of blast-furnace treatment on a large scale.

The cost of production even on a large scale at Butte, Montana, U.S., was estimated to equal £44 6s. 8d. per ton in 1895.*

Going back no further than 1881, according to the admirable statistical return compiled by Henry R. Merton & Co., London (which is appended), in 1885, 1886, and 1887 the average market value of copper was below this figure, having fallen from £61 1s. 3d. in 1881 and £67 in 1882 to £40 6s. in 1886. In 1888 it rose suddenly from £42 3s. in the previous year to £76, under the unhealthy stimulus of the (futile) effort of the Société des Metaux to corner the market. Rising to £54 1s. in 1891, it dropped again to £42 2s. 6d. in 1894, since when it has shown a steady upward rise to £49 10s. in 1897, with a still higher average for 1898.

In view of the modern advantages of cheaper freights and improved processes and machinery, which tend to counterbalance depreciating yields by larger and more rapid output, it is reasonable to anticipate that mines closed in the early days owing to adverse circumstances, rather than exhaustion, will yet yield profit for capital invested. It must, however, be strongly emphasised that successful reopening is dependent not only on the size of a low-grade ore-body, but to a larger extent perhaps on its composition,

* Modern Copper Smelting, 7th edition, p. 20.

which determines the possibility of direct furnace treatment or mechanical concentration. Direct pyritic smelting affords the most economic and rapid reduction of quantity, which is a *sine qua non* in low-grade problems. This interesting subject will receive further attention in another section of this work.

Not only in working the present active mines, but also in reopening old ones from which the richer surface ores have been removed, every advantage offered by cheapened freights and fuels, more efficient processes and machinery, combined with strictest economy in mining and supervision, must be utilised to offset gradually depreciating ore tenor, increasing haulage, and augmenting water, which assuredly wait on depth.

Nor should the value of the accumulated mine water be overlooked when reopening after years of enforced idleness, for it becomes saturated more or less with soluble salts of copper, which can be readily and cheaply extracted by means of metallic iron. The affinity of the sulphuric acid in the solution for iron being stronger than for copper, the latter is expelled in the metallic state, whilst the former enters into combination with the acid. Therefore, before unwatering, provision should be made for testing the quantity of copper in solution, and for preparation of vats lined with old scrap-iron for precipitating the metal, if the proportion is sufficient for profitable extraction.

As little free acid as possible should be present in the solution, otherwise a larger quantity of iron is dissolved without increasing the precipitation of the copper. Theoretically, according to Dr. Schnabel, 88·8 parts of iron are required to precipitate 100 parts of copper; in practice, however, the consumption of iron is considerably greater, owing to the presence of free acids.

The precipitating tanks at Rio Tinto are of brick, lined with plaster of Paris, and inside this with asphalt or Portland cement. Size, 6 ft. 6 in. x 6 ft. 6 in. x 2 ft. 6 in. The solutions traverse a series of these tanks. The consumption of iron is 1·12 parts to 1 part of copper.*

Milburn Creek Mine might be quoted to illustrate the value of some copper-mine waters. An analysis by Mr. W. A. Dixon, F.C.S., F.I.C.,† of the Milburn Creek drainage water yielded copper at the rate of 328·9 grains per gallon, equal to 4·698 lb. per 100 gallons. The iron and steel tools left in the mine during suspension owing to litigation were speedily converted into hollow shells of metallic copper.

In connection with the question of reopening old mines, the mistake of excluding copper from the operation of the Mining on Private Lands Act is forcibly demonstrated. Practically all the first opened mines are situated on land acquired by Crown grant, or by mineral conditional purchase. There is little doubt that had copper been included in the Act few of the mines so situated would remain idle at the present time, when copper properties are attracting so much attention.

Development.

Perhaps the most noticeable and regrettable feature in the early workings of the majority of New South Wales mines, and, unfortunately, of many of the present also, is the almost, if not complete, absence of anything

* Handbook of Metallurgy, by C. Schnabel; English translation by H. Louis, 1898, I, p. 242.
† Ann. Rept. Dept. Mines for 1879, p. 37.

approaching system. Sufficient unto the day has been, and is, the evil thereof. Where rich ores occur the paramount object appears to be depletion, as speedily and cheaply as possible, without regard to the future. Rarely is a payable mine opened systematically by extending prospecting operations beyond actual stoping; in fact, proving almost invariably ceases at the very time it should be most vigorously prosecuted, viz., when dividends are being paid; and perhaps still more rarely is any reasonable portion of the latter set aside as a reserve against contingencies. Hence, when the richer ores are exhausted, or the known pay-chute ends, calls are necessary for improvement of plant, or the search which should have been synchronous with payable working.

Dr. Peters states* that the rich ores of Butte, U.S., furnished the capital that was needed to design and construct the improved plants, and to gain experience necessary for treating the lower-grade ores at a profit; unfortunately, this has not been the case with certain well-known copper-mines in this Colony.

The necessity for timely proving is peculiarly essential in copper-mining, if any enlightened and progressive system is to be adopted in lieu of the hand-to-mouth policy which robs the mine of its richer ores, leaving the poorer to bear alone the steadily increasing cost of extraction and possibly of treatment. A more reasonable method would appear to be that which speedily opens up the sulphide resources beneath the richer oxidised and secondary ores of the surface zone, and not alone in depth, but longitudinally and laterally, proves the deposits and the barren intervening blanks.

One of the first requisites is proof of the vertical extent of the richer ores of the oxidised and redeposition zones, and the nature and quality of the poorer but more permanent sulphides beneath.

The oxidised and sulphuret ores are natural fluxes one for the other; hence it would appear more profitable to open up the latter and work them with the former, as far as these are available, instead of procuring barren fluxes, often at considerable cost, and thus introducing into the furnaces unproductive material, and thereby proportionally lessening their useful capacity.

Again, the necessity for timely proof of the nature of the sulphides, or rather of their matrix, is clearly an urgent matter, for frequently, as at Mt. Hope, Great Central, Girilambone, Cobar Chesney, &c., concentration, with its attendant costs, has to be faced. Few mines offer the exceptional advantages of a Great Cobar or a Nymagee, where the solid pyritic matrix affords a most kindly fluxing base in blast-furnace treatment; and, moreover, offers a ready and efficient means of treating gold and silver ores as fluxes in the process. This important advantage will be more fully discussed when the above mines are under description.

Apart from the metallurgical advantage derivable from proper blending of the different grades of ore in a mine, another equally desirable end is gained, viz., regularity and equality of output, which alone render mining a sound and secure investment. Command of rich and poor ores in a deposit may, unfortunately, be also used for the ignoble ends of market riggers and share gamblers; but fluctuating yields, either through lack of system or through design, must always react at the expense of legitimate mining and security.

* Modern Copper Smelting, 9th ed., 1898, p. 19.

Low-Grade Deposits.

Until the present Cobar Mining Syndicate began operations in 1893–4, when the local copper was realising but £39 per ton, the successful treatment of low-grade copper ores was solely dependent upon the value of the copper contents, no allowance being made by purchasers for the associated gold and silver in certain brands of copper, which must have been an important source of profit to them. This serious defect has now been remedied, the full market values of the associated metals, less cost of extraction, being obtained. Still the additional advantages enjoyed by European smelters of realising the values of by-products is not yet possible to those of Australia. The Tharsis Copper and Sulphur Co., of Glasgow, affords, perhaps, the most signal example in this respect. Working the low-grade cupriferous pyrites of the Spanish Peninsula, containing barely 3 per cent. of copper, and traces only of gold and silver, it is enabled, through realisation of the by-products, to declare a dividend of 25 per cent. for the half-year ending 30th April, 1897, bringing the average dividend for the thirty-one years of its existence up to 18⅓ per cent, having during this period paid to the shareholders £6,008,432, and written off £2,029,574 from the original values of £2,533,598. Theoretically, the only loss in its operations is the scrap-iron used in precipitating the copper from solution, each of the component minerals in the ore being turned to commercial account. A short description of the interesting Tharsis process, from notes made by the writer during a visit to the Company's Glasgow Works in 1890,* will, no doubt, be of interest to Australian copper-miners.

"During my stay in Glasgow through the courtesy of the Proprietary I was enabled to visit the Tharsis Copper Reduction Works. The Spanish ore treated at these works consists chiefly of iron pyrites with a percentage of copper pyrites equal to about 3 per cent. of metallic copper; the sulphur being equal to from 46 to 48 per cent.; very small quantities of gold and silver are also present. The ore is first roasted at the Sulphuric Acid Works, in the immediate vicinity, to obtain the sulphur, about 4 per cent., however, being purposely left in the calcined ore; it is then mixed with 16 per cent. of salt and charged into roasting furnaces in charges of about 3½ tons exclusive of the salt. The furnaces are known as blind muffles, the ore being within a central brick oven out of contact with the flames. The roasting continues for about ten and a-half hours. The fumes are led from the muffles into towers containing coke, over which water is constantly trickling, which absorbs the gases given off. A small proportion of gold is carried down in the acid solution, and is precipitated along with the other metals present by a small quantity of sulphide of calcium, which is allowed to trickle into the solution at the points where it issues from the base of the towers into the settling vats. The clear acid solution, which contains about 30 grains of copper per gallon, is in part used for washing the roasted ore, the balance being treated with scrap-iron to precipitate the copper.

"The roasted ore is thrown into vats and hot water pumped on to the top; as it percolates through the mass it dissolves the soluble copper salts formed by roasting; the copper solution passes through the filter bottom into the adjoining compartment. The ore is then discharged into another vat and rewashed, the weak solutions being constantly charged into the ore vats until they attain a certain strength. The gangue is washed until no appreciable quantity of copper is left; the completely decopperised gangue, after exposure and oxidation, is known as "blue-billy," and is sold to the iron foundries for fettling purposes. The strong copper solution is pumped into

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* Ann. Rept. Dept. Mines N. S. Wales for 1890, p. 278.

vats and treated with iodide of zinc to precipitate the silver; the solution is after a time drawn off and treated with iron scrap to precipitate the copper in the metallic state; the resulting copper scale is washed and then smelted into ingots in the ordinary way.

"The precipitates obtained with the sulphide of calcium and iodide of zinc are sent to Birmingham for treatment. In the above interesting and economic process there is, therefore, no waste, save the unavoidable losses of manipulation, all the commercial constituents of the ore being extracted."

A day at Cobar, Lithgow, or Captain's Flat is forcibly convincing of the great, yet probably unavoidable, loss of valuable material, viz., sulphur, that is being continuously volatilised into the atmosphere, particularly from the roast-heaps at Cobar. Unfortunately, local conditions prevent its utilisation in the manufacture of sulphuric acid, as is the practice of European countries where protection of vegetation, apart from commercial advantage, compels preventive measures against the disastrous effects of sulphuric acid gas, more particularly in humid climates. Fortunately, or unfortunately, little loss is likely to accrue from the latter cause at Cobar.

Where smelting operations are carried on in centres of population, the fume nuisance is capable of abatement by erection of tall chimney-stacks, by means of which the noxious gases become largely diluted with air before reaching the ground. Experiment has proved that the other volatile substances discharged into the atmosphere in copper-smelting are practically inert, or too diffused to be objectionable.

The mono-sulphide—pyrrhotite or magnetic iron pyrites—which is common in copper lodes, and in considerable proportion in some of those of the Blayney District, and is also present in the Cobar lode, is of little value for sulphuric acid manufacture, as it contains but one atom of sulphur against two in the ordinary pyrite, and requires greater heat for its expulsion. It is, however, of equal calorific power to the bisulphide in pyritic smelting, owing to the volatilisation of one atom of sulphur from the latter in the native state.

In Wright and Osborne's Mine, near Blayney, the transition from oxide of iron—partly magnetic—in the cap of the lode through massive pyrrhotite to ordinary pyrite and chalcopyrite, is due to the gradual elimination of the sulphur, the less stable atom in the pyrite being first removed.

Of recent years, large bodies of low-grade cupriferous sulphides have been much sought for, the most important ventures in this direction being the Mount Lyell of Tasmania, and the Lake George Mines of Captain's Flat, New South Wales; the former realising the estimates of the well-known copper expert—Dr. Peters, junr.—the latter, on the other hand, falling short of the estimated returns of those connected with its flotation.

How low a grade may be profitably exploited depends upon local conditions and the nature of the ores. If gold and silver be present, even in comparatively insignificant proportions, an ore capable of pyritic treatment on a large scale, containing even 2 per cent. of copper, will, under favourable circumstances, yield a profit. It is, indeed, remarkable upon how little depends the profitable or unprofitable operation of such deposits on a scale of great magnitude; the almost infinitessimal gold and silver contents may represent the difference between profit and loss. Even at the famous Butte Mines of Montana, U.S. (according to Dr. Peters*), it may be assumed that the net profits are mainly derived from the silver contents, which amount to about 5 oz. per ton of 2,000 lb., in copper ore now averaging about 6½ per cent. Deducting the losses in concentration and smelting, the net yield of the Butte ores is 5 per cent. copper, and 4 oz. (0·014 per cent.) silver. †

* Modern Copper Smelting, 9th ed., 1898, p. 20. † *Ibid.*, 9th ed., 1898, p 19.

The smelting yield of the Great Cobar ores is estimated at the present time to average about 3¼ to 4 per cent. copper, and 2½ dwt. of gold per ton. The actual returns of gold and silver are, however, difficult of estimation, owing to complication arising from admixture of gold and silver ores from the neighbouring Great Peak Mine as fluxes.

In one respect, paradoxical as it may appear, auriferous, low-grade, copper deposits possess a distinct advantage over richer, viz., the extreme smelting concentration necessary to produce a profitable matte from poor copper ores, brings their small gold and silver contents within the range of profitable extraction, which is an impossibility in low concentration, owing to the cost of electrolytic separation. The ratio of concentration during the two campaigns at Lake George Mines (Ld.), Captain's Flat, has averaged 27 tons of ore to 1 ton of 30 per cent. matte.

The proximity of siliceous flux, having of itself considerable value, is an important factor in the determination of the profitableness of any low-grade pyritic lode.

The regrettable failure of the first operations of the Lake George Mines turned on 1 per cent. of copper. The pyritic smelting adopted, after the initial difficulties had been overcome, reached so fairly high a pitch of economic efficiency that a smelting yield (according to the Company's certified returns) of a shade over 1 per cent. of copper, and proportionately small yields of gold and silver, amounting in aggregate value from 22s. to 23s., only failed by about 5s. 6d. per ton to pay cost of mining and smelting. An additional per centage of copper at the market rate would have turned the balance between profit and loss.

It is gratifying, however, to know that the temporary failure of the Company's first operations has resulted in the achievement of phenomenal reductions in cost of production, under the skilful treatment of a young Australian metallurgist—Mr. A. W. Hudson—which, combined with strictest economy in mining and supervision, has established a record, viz., a cost of 14s. 9d. per ton of ore for mining, smelting, and general expenses;* this result is best appreciated after a study of the refractory composition of the ore in question, which is fairly represented in the following analysis by Mr. H. P. White, F.C.S., Assistant Analyst to the Department of Mines and Agriculture.,† of an average sample selected by Messrs. Jaquet and Watt, Geological Surveyors, from the various exposed faces at the 400-foot level.

ANALYSIS.

Moisture at 100° C.	0·10
Combined water	0·65
Insoluble in acids (gangue)	23·70‡
Metallic iron	17·75
,, zinc	14·50
,, lead	8·04
,, copper	1·11
Sulphate of lead ($PbSO_4$)	0·32
Alumina (Al_2O_3)	1·36
Lime (CaO)	0·40
Magnesia (MgO)	0·65
Sulphur trioxide (SO_3)	0·25
Carbonic acid (CO_2)	2·08
Phosphoric acid (P_2O_5)	0·57
Sulphur (S)	27·97
Oxygen, and undetermined	0·53
	100·00

* The Lake George Mines Co. (Ltd.) vouches for the correctness of these figures.

† Ann. Rept. Dept. Mines & Agric., for 1897, p. 21.

‡ NOTE.—91·35 per cent. of the gangue consists of silica, the remainder containing alumina, magnesia, and alkalies. The gold contents averaged 1 dwt. 12 grs., and the silver 2 oz. 8 dwt. 14 grs. per ton.

The actual smelting returns from over 90,000 tons of ore furnaced by the present Company abundantly verify the accuracy and thoroughness of the sampling represented by this analysis.

For comparison it is interesting to note the cost of mining, smelting, and development at Mount Lyell, Tasmania. For the half-year ending 31st March, 1897.* The following costs are quoted:—

	£	s.	d.
Mining operations	0	2	4·64
Removal of overburden	0	2	0
Smelting operations	0	17	9·87
Converter	0	2	9·18
	£1	4	11·69

Deducting the converter charge, the cost of producing a 50 per cent. matte amounts to £1 2s. 2·51d. per ton of ore treated. The Mount Lyell ore is, however, favourably distinguished from that of Lake George Mines, by greater richness and freedom from refractory associates.

Abundance, and a kindly matrix are indispensable conditions in low-grade deposits; the dimensions should be such as to allow of continuous economic winning without excessive deadwork.

The composition of the matrix and the proportion of sulphur are most important factors, for upon these depend the nature of the treatment. If largely pyritic, smelting is greatly simplified, the hot-blast process being most suitable and economic.

A siliceous (quartz) matrix, from its great infusibility and consequent heavy fluxing requirements (2 lb. of basic flux to 1 lb. of silica), is, perhaps, the most intractable. The silica, however, should be kept above 24 per cent. A deficiency of silica or excess of iron in the slag interferes with the separation of the matte, as it increases the specific gravity of the former.

With pyritic ores a considerable amount of silica—from 30 to 40 per cent.—can be safely included in the blast-furnace charge, to form a fluid silicate of iron slag. The range of silica in an ideal slag lies between about 30 and 38 per cent., but it is unquestionable that a considerably higher limit is possible, and that advances are anticipated in this direction in the near future of metallurgy. This interesting and important question receives more extended consideration is the second part of this work under the head of Great Cobar.

Ores containing an excess of silica and deficient in iron and sulphur are better suited for reverberatory furnaces, as a large proportion of unfused quartz can be floated off in the slag of a reverberatory furnace without impairing the separation of the matte. Lean, siliceous, sulphide ores, however, require concentration before effective independent smelting is possible. Oxide of iron, or, better still, ferruginous slag from matte roasting, is the best flux for silica.

The following *résumé* from a paper on Copper Smelting by Mr. H. M. Howe, A.M., S.B.,† on the advantages of the two forms of furnaces, Cupola (blast) and Reverberatory, is extracted from Modern Copper Smelting, Fifth Edition, 1892, p. 258:—

Furnaces.

For smelting ore the Cupola is specially advantageous—

"1. With highly ferruginous ores.

* Tasmania and its Mineral Wealth, special edition of Austr. Mining Standard, 1st July, 1898.
† Bull. U.S. Geol. Survey, 1885, No. 26.

LAKE GEORGE COPPER MINES, CAPTAIN'S FLAT.

(Southern Section, showing Smelting Works and Commodore Shaft.)

"II. Where the cost of anthracite, coke, or charcoal is not excessively greater than that of bituminous coal, wood, and other fuels fitted for the reverberatory only.
"III. For oxidised ores.
"IV. For low-grade native copper.
"V. Where, as in the case of lean ores, clean slags are a necessity."

The Reverberatory is especially advantageous—
"VI. With highly refractory siliceous, aluminous, calcareous, or magnesian ores.
"VII. Where the composition of the ore changes suddenly and greatly.
"VIII. Where bituminous coal, wood, or other reverberatory fuel is very much cheaper than anthracite, coke, or charcoal.
"IX. For smelting and immediately refining rich native copper.
"X. Its disadvantages in yielding richer slags than the Cupola weighs less heavily in case of rich ores."

The application of the principle of pyritic, or partial pyritic, smelting is of very recent date, and in Australasia but three instances are known to the writer, viz., at Mount Lyell, Captain's Flat, and Nymagee. The Great Cobar Syndicate has, however, decided to adopt it at Cobar. As, therefore, pyritic smelting is comparatively little known, rather full extracts have been made from the writings of Dr. Peters, junr., and Mr. Robert Sticht, of Montana, illustrating its principle, scope, and results.

Pyritic Smelting.—"Pyritic Smelting—Its History, Principles, Scope. Apparatus, and Practical Results," is the title of a very interesting and instructive article by Mr. Robert Sticht, of Montana,* from which extracts have been made, as well as from the chapter on the same subject by Dr. Peters.† To quote the latter, "Mr. W. Lawrence Austin, of Denver, Colorado, is fully entitled to the credit of carrying out to a commercial success the principles that John Hollway of London proved to be practicable" [in 1878, according to Sticht, J.E.C.]

Pyritic smelting is defined by Dr. Peters as "The fusion of sulphide ores by the heat generated by their own oxidation, and without the aid of extraneous heat, such as carbonaceous fuel, the electric arc, &c."

Its object, according to Mr. Sticht, is "to make the pyritic, or other sulphureted materials of the ores, act in a unique and threefold capacity viz:—
"1. As a fuel.
"2. As a collector of the precious metals, as also of the copper, nickel, &c., present.
"3. As a flux, or slag-making factor."

From Dr. Peters summary of pyritic smelting the following abstracts are taken:—
"1. Genuine pyritic smelting (without the aid of any carbonaceous fuel) demands exceptionally favourable ores.
"2. Partial pyritic smelting, with the aid of a hot blast, and the addition of from 1·5 to 5 per cent. of coke to the charge, is an assured success, and may, under proper conditions, be the most economical method that can be employed.

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* Peters—Mod. Copper Smelting—9th ed., 1898, pp. 396-401.
† *Ibid.* pp. 372-395.

"3. Both pyrrhotite (magnetic pyrites) and matte make excellent materials for this process, pyrrhotite affording practically about as much heat as does iron pyrites, owing to the loss of the first atom of sulphur in the latter mineral, by volatilisation as metallic sulphur. The oxidation of the iron probably furnishes as much effective heat as the burning of the remaining atom of sulphur.

"4. Arsenic and antimony are more thoroughly removed and cause less trouble than in ordinary smelting. Zinc and lead sulphides are about equally deleterious in the new, as in the old, method of smelting. Heavy spar works particularly well in a pyritic furnace, the baryta being slagged and the sulphuric acid decomposed and escaping as gas, instead of augmenting the quantity of matte, as in ordinary blast-furnace work.

"5. The recovery of the precious metals is as good in pyritic as in ordinary smelting, and the slags are equally clean.

"6. The rate of concentration is very satisfactory under proper conditions, and can, in the main, be regulated at will, according to shape of furnace, volume and pressure of blast, fusibility of charge and rapidity of driving, and amount of carbonaceous fuel added.

"7. A plant for pyritic smelting can be erected at least as cheaply as one to produce similar results by the ordinary methods."

The advantages of pyritic smelting are (*a*) the enormous saving effected in cost of fuel as compared with ordinary blast and reverberatory methods; (*b*) saving the initial cost of roasting or calcining plant, with the labour attaching thereto, and the additional handling of the ore; (*c*) the production of cleaner and more siliceous slags, the latter an object of great importance in many localities (Cobar, for instance) where gold and silver ores can be worked with the copper, for by keeping the slags siliceous these metals may be concentrated to any reasonable extent.

In rare instances where the ores are very suitable, carbonaceous fuel can almost entirely be dispensed with; usually, however, from 3 to 5 per cent. (coke) is used. In ordinary smelting in the United States, Dr. Peters estimates the proportion of coke in the blast furnace as fully equal to one-sixth of the weight of ore; and the combined cost of fuel in roasting and smelting as about equal to 60 per cent. of the total cost, the difference in cost of fuel between pyritic and ordinary blast furnaces smelting being equal to 40 per cent. in favour of the former.

Mineral Associates of Copper Ores injuriously affecting Smelting Operations or the Quality of Copper.

The presence of sulphides of zinc and lead, especially the former, add greatly to the troubles of the smelter, owing to their tendency to choke the furnace by forming a crust in the throat, necessitating frequent "barring-down." The effect of zinc sulphide (blende) in copper-smelting is stated by Mr. Sticht, in "Peters' Modern Copper Smelting,"* to be that part only is oxidised and enters the slag to that extent; it is also deposited in the furnace throat. "A greater portion of it in its unaltered chemical state is held in solution in the slag chemically or merely mechanically. Another portion enters the matte, and the balance escapes as fumes, part of which is sublimated and regenerated in the upper and cooler regions of the furnace shaft." "Its immediate action is to vitiate the separation of the matte and slag by decreasing the specific gravity of the former."

* 7th edition, p. 424.

Another authority quoted—Herbert Lang—in the same work* refers to the influence of zinc blende on smelting operations, as follows:—"Zinc enters the slag as oxide and the matte as sulphide, rendering the former viscid, the latter light, and by injuring the separation diminishes very seriously the saving of the precious metals. By volatilisation as metal or oxide it causes heavy loss of silver."

At Lake George Mines, Captain's Flat, zinc enters the slag to the extent of 14 or 15 per cent., and into the matte from 9 to 10 per cent.

Dr. Schnabel states that large quantities of zinc form with the slag and a portion of the matte, a porous mass called *skumnas* (scum or foam) in Sweden, from which the copper can only be extracted with great difficulty." He advises the conversion of zinc sulphide as far as possible into oxide during roasting, carbonaceous matter being mixed with the ore during calcination to decompose any basic sulphate formed during the operation.†

The difficulty of dealing with zinc sulphide on an economic commercial basis is a serious problem confronting the silver-mining industry of New South Wales with which it is so largely associated, especially at Broken Hill, as to render the future of the industry almost dependent upon a satisfactory solution of the question.

The principal copper mines of the Colony, so far, have been fortunately free from serious zinc troubles. A thin skin of zinc blende occasionally coats either wall of the Cobar lode; but the quantity is so slight compared with the mass of the ore that it can be disregarded. At Peelwood it was unpleasantly prominent in the lowest workings; at Apsley, Wiseman's Creek, and Captain's Flat mines it is intimately associated with the copper sulphide.

The amount of zinc that may be introduced into the furnaces depends largely upon surrounding conditions; but it is noteworthy that in Customs Smelting Works any excess of zinc over 10 per cent. carries a deduction of 1s. per unit. To quote the tariff of the Walleroo Smelting Company, of South Australia: "In no case will any zinc be paid for, and for all zinc over 10 per cent. a deduction will be made at the rate of 1s. per unit." The rates quoted for copper ores in the tariff issued by the Great Cobar Mining Syndicate in connection with its Lithgow Refining Works, are stated to be for copper ores free from impurities. The smelting charges for ores containing arsenic, antimony, tin, zinc, bismuth, &c., are higher than the ordinary, and vary proportionately with the nature and quantity of the impurities present.

The tariff of the Smelting Company of Australia, Dapto, provides for a smelting charge of 40s. and 50s. per ton for oxidised and sulphuret copper ores containing arsenic or antimony. These charges cover 5 per cent. of either; for any excess a charge of 1s. per unit is added.

The effect of zinc entering the matte as sulphide, in copper-smelting, must be to seriously diminish realisation values of such material, as its deleterious effects manifest themselves in refining.

The effect of metallic zinc on copper is variously stated by the following authorities:—

Bruno Kerl states‡ that "0·6 per cent. of zinc produces red-shortness, to a degree cold-shortness, whilst many alloys of copper with zinc (malleable brass) are malleable between certain limits of temperature."

* *Op. cit.* 1896, p. 79.
† Handbuch der Metallhüttenkunde. Translation by H. Louis. Vol. I, p. 89.
‡ Grundriss der Metallhüttenkunde, 1881, p. 230.

C. Schnabel* states "that zinc alloys itself with copper and diminishes the malleability of the metal when hot. A copper-zinc alloy, with more than 20 per cent. of zinc, is at all temperatures less malleable than copper."†

C. Stölzel, in his book "Die Metallurgie," Vol. I, p. 618, 1886, states that copper containing 0·6 per cent. of zinc and 0·25 per cent. of tin causes the metal when beaten out under the hammer to show fractured (rugged) edges.

Bismuth, however, is the most injurious impurity in copper, as very small quantities render the copper unworkable. Dr. Peters states that "it clings to copper with much tenacity, and affects its properties in a most surprising manner."‡ Hampe, quoted by both Dr. Peters and Dr. C. Schnabel, of Clausthal,§ states that copper containing as little as 0·02 per cent. of bismuth is red-short, and 0·05 cold-short, the term "red-short" signifying brittleness when red-hot, and "cold-short" brittleness when cold. The same authority also states that with 0·1 per cent. of bismuth copper crumbles under the hammer at a red heat, and that the tendency to cold-shortness is somewhat counteracted by the presence of a certain proportion of antimony. Schnabel and Louis state|| that oxide of bismuth which is mechanically taken up by copper affects it like the metal, but in a less degree as far as cold-shortness is concerned, its effect being further diminished if the bismuth oxide is combined with cuprous oxide.

Bismuth is present in the Great Cobar lode, and is doubtless accountable for the lower market value commanded by its product. In a series of analyses by Mr. W. A. Dixon, F.C.S., F.I.C., of the oxidised ores worked in 1878, bismuth was found to be present in proportions ranging from 0·21 to 2·58 per cent.¶ The same authority analysed the copper made from these ores in 1879,** which he described as somewhat difficult to refine, and not coming to the proper "tough pitch," owing to the presence of bismuth. Following are the results obtained:—

Copper	99·346
Bismuth	·419
Iron	·083
Lead	·086
Silver	·026 = 8 oz. per ton.
Antimony	·029
Traces of arsenic, nickel, cobalt, gold, and loss	·011
	100·000

Arsenic usually in the form of mispickel is one of the commonest and most objectionable associates of copper ores. Arsenic, and also antimony, though very volatile, readily combine with the metallic bases, forming combinations difficult to split up. This affinity necessitates keeping the metal in the copper refinery at a high temperature for an excessive period to allow for volatilisation, a process involving great destruction to the furnace linings. The removal of arsenic is assisted by the addition of pyrites during calcination, which volatilises a portion as sulphide of arsenic.†† At Sunny Corner realgar and orpiment (sulphides of arsenic), by their bright red and yellow colours, characterised the roasted ore.

* Handbuch der Metallhüttenkunde, 1894, Vol. I, p. 3.
† *Ibid*, Trans. by H. Louis, 1898 I, p. 3.
‡ Modern Copper Smelting, 9th ed., 1898, p. 2.
§ Handbuch der Metallhüttenkunde. Trans. by H. Louis, 1898 I. p. 3.
|| *Ibid*, p. 4.
¶ Ann. Rept. Dept. Mines for 1878, pp. 38–41.
** Ann. Rept. Dept. Mines for 1879, p. 29.
†† Schnabel and Louis' Handbook of Metallurgy, I. p. 25, 1894.

Dr. Peters states that arsenic has a greater affinity for metallic copper than for matte; hence, if the smelting charge be so regulated that there shall be an insufficiency of sulphur to combine with the copper, the product of a quick fusion will be a considerable quantity of rich matte comparatively free from arsenic and a much smaller quantity of very impure metallic copper known as "metallic bottoms."*

The effect of arsenic on copper was formerly regarded as highly injurious, even $\frac{1}{1000}$ of arsenic producing both red and cold shortness, but Schnabel† quotes Hampe‡ to the effect that 0·5 per cent. of arsenic produces no bad effects; only when the proportion rose to 1 per cent. could a slight degree of red-shortness, but no cold-shortness, be detected. According to the same authority, copper with 0·8 per cent. of arsenic could be drawn into the very finest wire, and small percentages of arsenic (0·216 per cent.) even increase the tenacity of copper. According to Stahl,§ a small amount of arsenic prevents copper from becoming porous.

Professor W. C. Roberts-Austen‖ states that arsenic materially increases the electrical resistance of copper; on the other hand, it increases its durability when used in locomotive fire-boxes.

The action of lead on copper is stated by Schnabel, on the authority of Hampe's recent experiments to be that 0·15 per cent. does not affect the malleability of copper in any way; with 0·3 per cent. of lead it becomes slightly red-short, and with 0·4 per cent. slightly cold-short. With 1 per cent. of lead copper is unworkable.

Antimony in small quantity, according to the same authority, does not affect the good qualities of copper. With 0·529 per cent. copper can be drawn into the finest wire equally as well as pure copper. One per cent. of antimony, however, renders copper extremely red-short. It likewise impairs its electrical conductivity.

Hampe's latest experiments¶ show that silicon (the metallic base of quartz) hardens copper without impairing its toughness or its malleability when less than 3 per cent. is present. With 6 per cent. of silicon copper becomes brittle; with 8 per cent. it is readily pulverised, and with 11·7 per cent. it is as brittle as glass. The electrical conductivity of copper is impaired by small proportions (0·52 per cent.) of silicon.

The process of copper-refining depends upon the rapid oxidation of the impurities usually associated with copper, and their greater affinity for oxygen; the less oxidisable impurities, however, by the protracted "roast" required for their elimination cause great destruction to the furnace hearths. According to Dr. Peters** a considerable part of the injurious substances can be extracted by exposing the pigs of matte to a slow oxidising fusion, the operation being interrupted as soon as a certain amount of metallic copper is formed when the furnace is tapped; the small quantity of copper thus produced contains not only the greater part of such impurities as arsenic, antimony, tellurium, tin, &c., but also the gold contents. The great affinity of gold for metallic copper and its unoxidisability renders it possible to concentrate it, and, owing to the latter quality, it would be theoretically possible to oxidise and slag off the copper, leaving the precious metal behind.

* Modern Copper Smelting. 5th ed., 1892, p. 339.
† Handbuch der Metallhüttenkunde. Transl. by Louis 1898 I, p. 4.
‡ Chemiker-Ztg. 1892, 16, No. 42.
§ Inaugural Dissertation. Turbingen, 1886.
‖ An Introduction to the Study of Metallurgy, 1894, p. 11.
¶ Chemiker-Ztg., 1892, 16, No. 42. (Schnabel and Louis, I, 1898, p. 5.)
** Modern Copper Smelting. 5th ed., 1892, p. 378.

CONCENTRATION.

In connection with the lower levels of copper mines in which the copper and iron sulphides are leanly distributed through the lodestuff, a prevalent hope is indulged that increasing depth will reveal increasing solidity or concentration of these minerals. Certainly instances are not wanting of such a desideratum, but their rarity and transiency but emphasise the necessity for resolutely facing the problem of concentration, for the hope of richer ore-bodies with depth vanishes in the light of experience. Below the water-level gradual depreciation almost, if not invariably, is associated with depth.

Concentration of lean ores is a question looming large in the future of copper-mining in New South Wales, as the grade of the available ores in the principal producers is low and falling, necessitating increasing outputs to maintain returns. In fact, an optimistic view of the industry is not possible, though discovery may at any time change its aspect. The rich ores of the important mines have been exhausted, and no later discoveries of equal magnitude and richness stand ready for development. At Girilambone, Mount Hope, Great Central, and the Cobar Chesney Mines, mechanical concentration is a problem to be resolutely faced. Great Cobar, thanks to the kindly nature of its ore, is amenable to furnace concentration. At Burraga immense heaps or "burrows" of lean siliceous sulphides, discarded from the direct smelting "firsts," await concentration. The absence of permanent water supply in the far western copper-fields increases the difficulties to be overcome, which in themselves are sufficient to tax the ingenuity and skill of the most experienced manipulators.

At the first three mines concentration on a primitive system has already been adopted, and at two—Girilambone and Mount Hope—large reserve heaps of "seconds" from the jigs await further treatment. In both cases the "seconds" consist chiefly of fragments of earthy and siliceous carbonates in slate and fine-grained sandstone, the difference between the gravity of this class of ore and the waste being so slight as to defy mechanical separation beyond a certain unsatisfactoy point. In connection with the "seconds" at Girilambone, the Writer gave some attention to the possibility of mechanically separating the particles after careful sizing, but the difference between the specific gravities of even the richest ore-particles (azurite) and the waste was so slight—0·73—as to render mechanical separation impossible. The green carbonate particles, which are also conspicuous in the "seconds," need only a glance to reveal the fact that their copper contents are more apparent than real; the green particles are mostly quartz-stained with malachite, the specific gravity of which is about 2·74, and that of the waste 2·72. Even the translucent crystals of azurite (blue carbonate) contain but 31 per cent. of copper instead of the 53·2 per cent. of the pure mineral.

Though no tests were made with the earthy carbonates of the New Mount Hope and Great Central Mines, it is probable that to a large extent the same difficulties will be encountered.

These considerations open up the question of the possibility of a leaching process with sulphuric acid being adopted, the acid being manufactured in chambers on the spot from the roasting of lump sulphides from lower levels. Unfortunately, in some of the mines mentioned, so far as the pyritic zone has been pierced, the sulphides of both iron and copper are leanly distributed through the matrix, and therefore unsuitable for the purpose without previous concentration. Given sufficient sulphides suitable for producing sulphuric acid, the process is worthy of serious consideration, as a similar means of extraction has been adopted for lean oxidised ores by the Arizona Copper Company, at Clifton, Arizona, U.S.*

Carbonates and oxides of copper can be dissolved by hydrochloric and sulphuric acids, ferrous chloride, ammoniacal compounds, hyposulphate of soda, and ferrous sulphate; but the first three alone have been practically employed. The two first act very energetically.

At the World's Columbian Exhibition, Chicago, 1893, the Writer had the "Douglas Central Flue Revolving Cylinder Furnace" explained by means of a model by the inventor, Mr. James Douglas, President of the Copper Queen Mine, Arizona. In this furnace, which is used in connection with above-mentioned process, instead of the heated gases from the fireplace coming in contact with the ore charge, they are conveyed through the furnace by means of a central flue, and the charge is heated therefrom by radiation. The cylinder is of iron, lined internally with firebrick; the central flue is constructed of tiles kept in position by four tiles locked into the lining, these tiles extending the whole length of the cylinder, divide the ore-chamber into four compartments. The fire required to ignite the charge is contained in a movable furnace on wheels, which can be connected or disconnected at will from the cylinder. The air-draft into the ore compartments is regulated by means of an adjustable register, which closes the front or discharge end of the cylinder.

The internal flue is the main difference between the Douglas and Brückner revolving cylindrical furnace, and perhaps the only one so far as practical working is concerned.

For sulphuric acid manufacture the Douglas furnace offers exceptional advantages, inasmuch as it delivers the gases from the ore uncontaminated with any impurities from the fuel used in firing.

The divisions of the compartments are pierced at intervals with slots or openings, so that the ore can fall from one to the other, and thus increase the agitation.

The capacity of the furnace is about 6 tons per diem, when the ore is liable to sinter, owing to presence of lead or high percentage of copper; and up to 12 tons of pure pyrites. Owing to the inaccessible nature of the ore-chambers, ore liable to sinter at a low heat is unsuitable for treatment.

The speed of revolution varies from one revolution in three minutes to one in ten minutes.

A dust-chamber is a necessary adjunct of this furnace.

The vital question in concentration, however, refers almost solely to the sulphides which constitute the permanent sources of supplies, the oxidised ores at best being but superficial. The estimated copper contents of the sulphides under consideration range from 3 to 5 or 6 per cent. in gangues of slate, sandstone, and quartz; in the descriptive records of the individual mines concerned full particulars are given of the methods of concentration adopted. It is noticeable in the slate and sandstone country, wherein the lodes are mostly segregations or replacements, that where the ore is more concentrated quartz is a more or less abundant associate. Usually, however, the sulphides are sparingly distributed through the matrix. The most advantageous method of dealing with the ore as it comes to the surface is to carefully select all lumps capable of being dressed by hand to smelting grade, and to deal with these separately by spalling and picking. In siliceous lodes, such as Girilambone, Mount Hope, and Burraga, too much care

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* Mineral Industry, 1898, VI, p. 220, per J. Douglas.

cannot be given to this section, for, to quote a high authority,* "When ores are siliceous a mere rejection of such pieces of barren quartz or wall rock as have accidentally got among the ore, or first become visible on breaking up the large masses, may have a most beneficial influence on the subsequent fusion. Where the expense of treatment is high, and work is conducted on a large scale, the profits resulting from raising the average contents of the ore even a single per cent. is hardly credible, even aside from the increased fusibility due to the decreased proportion of the silica."

The second step in the process is the rejection of the waste mixed with the ore from the working stopes; after screening, the larger fragments could be broken and sorted by cheap boy or elderly labour; by these means a good proportion of actual waste could be at once discarded. In some instances it is unquestionable that a good deal of such material goes direct to the jigs and adversely affects the results proportionately with the quantity added, both as regards efficiency and capacity. There can be little doubt that the benefits of sorting will outweigh the cost, both directly and indirectly.

The sorted lodestuff, with the screenings and fines from the dressing of the "firsts," should then pass through the breakers to the rolls; the mesh of the trommel screens between the latter and the jigs should be regulated by the character of the ore, a second crushing being preferable to fine crushing in the first instance. Attempting to free all the scattered ore particles at the first crushing would, in the absence of an abundant water supply, increase, instead of reduce, the present loss, owing to the great tendency of some of the gangues to slime. If the seconds from the jigs offer sufficient inducement, then finer crushing and further jigging could follow, though better results would be obtained with buddles and vanners. Both the latter are in extensive use in Montana, United States, where fine crushing and concentration are carried out on a large scale. The Anaconda Company are understood to have adopted buddles wholly for the fines to the exclusion of vanners.

At the point of treatment indicated, it will be a matter for consideration, depending on the assay values of the seconds, whether it will not be more advantageous to waste a proportion of the ore than attempt to save it. This question has considerable weight where low-grade ore is abundant and fluxing bases scarce.

Theoretically, clean extraction, either mechanical or metallurgical, indicates good work, but the term "good work" is purely relative when commercially considered. However desirable it may appear to obtain clean tailings or slags, the cost of securing them may easily outweigh the advantage.

The form of jig most suitable for any class of ore must be decided entirely by practical test and observation. The Cornish, Handcock, and May Bros. machines are each represented in the Colony.

Concentration is naturally productive of an accumulation of "fines," which is unsuitable for furnace charging; metallurgists suggest several remedial methods of dealing with it, apart from covering or blinding roast heaps and stalls, if such be in operation, viz., mixing into balls with milk of lime and hydraulic cement, or with clay, or moulding into bricks in an ordinary pug-mill, as the finest material possesses inherent cohesiveness. The use of clay as a binding medium should be avoided, if possible, on account of the introduction of useless and refractory material into the furnace. Silicate of soda (water-glass) has also been tried, but its cost precludes extensive use.

* Dr. E. Peters, junr., Modern Copper Smelting, 5th ed., 1892, p. 54.

Permanence of Copper Lodes.

The permanence of copper lodes may be gauged by two factors—duration of operations, and actual depths of workings combined with extent of output. The first is applicable to deposits whose early history is obscured in the haze of intervening centuries; the latter, to mines in operation. In whichever light regarded, the prospect is cheering. Copper lodes, judging by history, are amongst the most persistent metalliferous repositories in Nature; it seems almost superfluous to add that this statement applies only to important occurrences.

Japan furnishes remarkable instances of the longevity of copper mines, which rank first in the mineral wealth of the country. In the "Mining Industry of Japan during the last twenty-five years—1867 to 1892"—by Wada Tsunashiro, Director of the Mining Bureau, Department of Agriculture and Commerce, it is stated that "Yoshioka and Osaruzawa Copper Mines, with several silver and gold mines, started in the 9th century, are still working and prosperous." At the World's Fair, Chicago, the writer was informed by Mr. Rejii Kanda, Mining Commissioner for Japan, that recent vertical shafts sunk under his engineering supervision to depths of over 1,000 feet, had revealed early workings extending even below that level. From these great depths the ore was carried to the surface in baskets on men's backs, through galleries or levels connected by short ladders. This primitive system of mining was admirably illustrated by models in the Japanese Mining Court at the World's Fair.

In England* the Cornwall tin lodes were worked in the time of the Phœnicians. With depth, copper ores replaced those of tin, and still deeper, the latter reappeared. Copper-mining in England began about 1700; previously the metal was obtained chiefly in connection with tin-mining.

The famous Tharsis and Rio Tinto Mines of the Spanish Peninsula were worked by the Romans, and are still in operation on a scale of great magnitude—1,372,376 tons of cupriferous pyrites were extracted by the Rio Tinto Company alone in 1895, making the total extracted by the Company to that date, 23,000,000 tons, with an estimated quantity in sight equal to 135,000,000 tons. The timbers in the old Roman workings have been so preserved by the copper salts in solution as to retain markings and letters cut by Roman miners eighteen centuries ago.†

A local instance of the preservative qualities of certain mineral solutions may be cited; the time-test, though comparatively extremely limited, is none the less effective. The timbers in the Moruya Silver Mine—the first silver mine opened in the Colony—laid down about 1861 or 1862—which have recently been exposed by unwatering the old workings, are in an excellent state of preservation. A more interesting fact, perhaps, is the condition of the ironwork: even the nails and ladder clips are capable of re-use; the latter, in fact, have been re-forged and used in the renovations. The Moruya ore is essentially arsenio-pyrite, with occasional zinc blende. The preservative agent is, therefore, probably chiefly arsenic.

Copper mines in Portugal, worked by the Romans, are still in operation. The celebrated San Domingos Mine yielded 196,922 tons of cupriferous pyrites in 1894 (p. 515).

Italian mines, worked bythe Etruscans, and during the Middle Ages, were brought to a standstill in 1630 for more than a century, when operations were resumed and are still in force, the 1,000-foot level being passed.

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* J. A. Phillips and H. Louis' Treatise on Ore Deposits, 1896, pp. 190 and 229. † *Op. cit.*, p. 500.

Swedish copper mines have been worked from a very remote period. According to Vogt (quoted by Phillips and Louis) the Falun cupriferous pyrites deposit has produced 1,200,000 tons of copper, equal to 35–40 million tons of ore, since the year 1200; and now produces annually about 500 tons of copper.

In India very ancient copper mines exist, but copper is now only produced on a very limited scale.

An idea of the permanence—or persistence in depth—of more recent mines can be gleaned from the following figures relating to some of the prominent American mines. Even under most favourable circumstances the duration of mines in this age of severe competition, and enormous outputs to meet increasing demand, must necessarily be comparatively extremely limited, when contrasted with early historic mines worked by primitive methods to satisfy restricted needs, though the actual extraction will probably compare most favourably. It is necessary to note that the Lake Superior copper deposits are not lodes in the ordinary acceptation of the term, but bed-deposits (conglomerates), flow-deposits (amygdaloidal lavas), and vein-deposits (small fissures in the igneous flows), which are followed on the incline.

Depths of American Copper Mines.

Name of Mine.	Depth—Vertical.	Depth—Inclined.	Dip.	Temperature.	References.	Remarks.
	feet.	feet.		degrees.		
Red Jacket, Lake Superior	4,900	....	..	87·6	United States Geol. Survey, 17th Ann. Rept., pt. 3, p. 94.	
*Tamarack, ,,	3,232	....	..	....	....	No. 1 shaft } Cutting the Calumet and Hecla bed on the underlay.
,, ,,	3,585	....	..	....	....	No. 2 ,,
,, ,,	4,450	....	..	....	....	No. 3 ,,
,, ,,	4,450	....	..	....	....	No. 4 ,,
,, ,,	....	....	..	....	....	No. 5 ,, expected to reach the ore at 4,700 feet.
Quincy, ,,	....	4,000	..	....	} E. D. Peters, Modern Copper Smelting, 5th ed., 1893, pp. 11, 12, and 23.	
Calumet and Hecla, Lake Superior.	2,310	3,800	37½	....		
Ely, Vermont	900	3,000 (nearly).	..	....		
Bute, Montana	1,800	....	..	....	*Ibid*, 7th ed., 1895, p. 20.	

The rich secondary (subsulphide) ores of Butte are estimated by Ledoux† to decline at the rate of 2 per cent. per 100 feet, but this diminution lessens, according to Dr. Peters, as greater depth is reached, and is now about stationary at 1,300 feet. The actual smelting yield at the present time is computed to be about 5 per cent. Owing to improvements in metallurgical treatment, and to consolidation of properties, the Butte mines are reported to be making more profit out of this lower grade than was possible with double the yield before.

The Lake Superior ores are reported to have an average value of 2·9 per. cent. of copper,‡ but some mines yield only ·75 per cent. The profitable working of these low-grade deposits to the immense depths quoted above

* According to C. Le Neve Foster (Text Book of Ore and Stone Mining, 1894, p. 36) a shaft is being sunk to enable the Tamarack Mine being worked to 5,000-feet level.

† Modern Copper Smelting, 5th edition, p. 20, 1893. ‡ *Ibid.*, p. 17.

depends upon the unique occurrence of the copper in the native state, which dispenses with costly reduction plants. The copper is so pure that simple concentration and melting are alone necessary to secure for it the highest market values.

Depths of New South Wales Copper Mines (Vertical or Inclined).

The depths attained in New South Wales are, comparatively, very superficial:—

	Feet.		Feet.
Burraga	800	North Wiseman's Creek	162
Nymagee	720	Summer's Copper Mine	155
Captain's Flat (Lake George Mines)	600	Bundarra	150
Cobar Chesney	560	Vychan	150
Girilambone	544	Goodrich	150
Great Cobar	*540	Copper Hill	146
Belubula	504	Quigley's Hill	140
New Mount Hope	400	Caroline	140
Frogmoor	373	Mount Carrington (Drake)	140
Blayney	300	Snowball	136
Icely	275	Bumbery (Payne's)	130
Burley Jacky	262	Cootralantra	130
Apsley	250	Murrumbidgee	125
Great Central	242	Mayfield (Burrowa)	125
Carangara	240	Nelson	120
Cadia	222	Bobby Whitlow	110
Britannia	210	Belmore (Cow Flat)	100
Milburn Creek	200	Mulloon	100
Ophir	200	Prince of Wales	100
Belara	200	Waugoola	100
New Burra Burra	200	Canoblas	96
Coombing Park	180	Cornish Mine (Bundarra)	90
Belmore (Byng)	180	Summerhill	90
Cow Flat	180	Adaminaby	80
Gurophian	170	Boro	80
Currowong (Lake George)	168	Lobb's Hole	80
		Moonta	60

Bedded Copper Deposits (Sedimentary).

The celebrated Keupferschiefer, or copper schist of Mansfeld, Harz, Germany, is the most important example of this form of deposit, apart from those of Lake Superior, which consist of lava flows with interbedded conglomerate. A brief description of its occurrence will be found in another portion of this work. It is alluded to here because it is approximately of the same geological age as the cupriferous tuffs overlying the Sydney Permo-Carboniferous Coal Basin. The Mansfeld copper-beds belong to the Permian period; those of Sydney to the passage-beds between the Triassic (Hawkesbury) Series and the Permo-Carboniferous Coal Measures of New South Wales. The latter will be described at some little length because of the scientific interest attaching to the occurrence, which otherwise has no value. The association of copper ores with Permian strata is as world-wide as it is remarkable. In Southern Russia, Germany, America, and Great Britain beds of the Permian, or a closely approximating period, contain copper impregnations. Those of America, in California, Colorado, and Mexico, according to Dr. Peters,† are of Triassic Age, and therefore more closely allied in time to those of the

* Tested to 660 by drill-borings. † Modern Smelting, 7th ed., p. 18.

Sydney Coal Basin, which have received a good deal of attention from Geological Surveyor David, B.A., F.G.S., now Professor of Geology at the Sydney University.

The American deposits are of special palæontological interest in that the copper ore—glance—replaces fossil shells, fish, and plants.*

In a paper read before the Australian Association for the Advancement of Science in 1887, Professor David stated "that cupriferous shales have been discovered at the following places:—

"1. At the 1,312-foot diamond drill bore, completed in 1879, at Newington, on the Parramatta River, near Parramatta, where it was observed by Mr. Waterhouse.

"2. At Bulli. The shale is said to outcrop on the hills at a level of about 700 feet above the Bulli coal-seam.

"3. At the 2,307-foot diamond drill bore, completed in 1887, at Dent's Creek, on the Holt-Sutherland Estate, between Port Hacking and Botany Bay.

"4. At the 1,586-foot diamond drill bore, completed in 1886, at Heathcote, on the Illawarra line, 27 miles southerly from Sydney.

"At Holt-Sutherland, out of a total thickness of 71 feet, at least 3 feet showed native copper, more or less freely. At Heathcote, about 7 inches of core altogether were cupriferous."

The following analysis of the tuff (Holt-Sutherland) has been made by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines:—

Combined moisture	5·32
Moisture at 100° C	3·38
Silica	56·28
Alumina	24·21
Oxide of iron	7·34
Metallic copper	·08
Lime	1·10
Magnesia	2·36
	100·00

Professor David, in the article quoted, discussed the economic value of the cupriferous tuffs, and summed up the question in the following terms:—

"At Holt-Sutherland the total thickness of the copper-bearing portions of the shales is at least 3 feet. This thickness, however, is made up of a number of different layers, several of which are separated from one another by bands of shale, which do not show copper freely, though they probably contain a small proportion of the same metals which occur in the more productive bands. The thickness of the metalliferous bands is respectively 1 inch, 2½ inches, 12 inches, 7½ inches, 5 inches, 2 inches, 2½ inches, and 6 inches. The highest ore band is about 24 feet above the lowest, and the beds are separated from one another by from 1 foot to 9 feet of comparatively barren shale.

"At Heathcote there are two thin beds showing native copper, the upper 6 inches thick, and 7 feet above the lower, which is only 1 inch thick.

"Assuming, therefore, that a continuous bed of cupriferous shale extends from Heathcote to Holt-Sutherland, a distance of 8½ miles, having an average thickness of 1 foot, there would evidently be a large body of metalliferous strata.

* Eng. and Mining Journal, 18th November, 1882.
† Trans. I, pp. 275–290.

"The average specific gravity being taken as 2·6, every acre of shale would contain 3,160 tons of copper-bearing rock, which would yield on the average (the average yield being assumed to be 0·15 per cent.) 3 lb. 5¼ oz. of metallic copper, and 7 dwt. 7 grs. of silver per ton. If, therefore, the value of the gold be left out of consideration, and, as already stated, gold was only found in appreciable quantity in one doubtful assay, the value of copper and silver in the aggregate would be only 3s. 9d. per ton, so that the shale is far too poor to work at present for these metals.

"The cupriferous tuffs and tuffaceous shales are evidently partly of volcanic and partly of sedimentary origin, as proved by the presence in them of both basalt lapilli and rounded quartz grains. Two facts indicate Kiama, or the line of volcanic country between Kiama and Mittagong, as the probable source of the volcanic particles; first, the presence of minute segregated veins of metallic copper in the basalt at Kiama; second, the resemblance of the Kiama and Mittagong lavas to those of which the fragments in the tuff at Holt-Sutherland are composed." . . . .

In three slides of the Kiama basalt Professor David detected minute segregated veins of metallic copper, about 1-40th of an inch thick. The local horizon of the cupriferous basalt has been designated the "Bomba" lava.

South Australian Copper Mines.

The first lode discovered in South Australia, according to Mr. H. Y. L. Brown, Government Geologist of South Australia,* was the Wheal Gawler, a silver-lead mine on the western slopes of the Mount Lofty Ranges, four miles east of Adelaide, opened in 1841.

The first copper-mine—the Kapunda—was discovered in 1842; the next in order being the Montacute in 1843, the Burra in 1845. The Moonta and Walleroo Mines were found between 1861 and 1864, and proved the richest in the colony. They are situated on Yorke's Peninsula, on the eastern shore of Spencer's Gulf. The Moonta and Walleroo Mines are about 9 miles apart, but are worked by the same company. The Moonta occurs, according to Mr. L. G. Handcock, in felspar porphyry, the Walleroo in metamorphic schist.

Mr. Brown describes the Moonta in the following terms:—

"There are five main lodes on the property, and from each of these various spurs and minor lodes branch out, and are connected with the main lodes by occasional cross veins. Including these there are twenty-seven lodes. Their direction is north-westerly, and their underlay varies from 3 to 6 feet in the fathom. The main lode bears N. 20° E., and the others vary from that up to N. 45° E. Their width ranges from 6 inches to 20 feet, and the ores obtained from the lodes in the present workings are chiefly chalcopyrite and bornite. The bulk of the veinstone—chiefly quartz, and at times portions of the bed-rock—as raised ore and gangue gives from 2 to 5 per cent. of copper, but sometimes clean chalcopyrite gives 20 to 30 per cent., and bornite from 30 to 50 per cent.

"The quantity of ore raised from the Moonta Mine from the commencement to June, 1886, equalled, in gross tons of 21 cwt.=476,180 tons, and the average percentage of copper on net dry weight of dressed ore equalled 20 per cent.

"The deposits of copper ore are chiefly along the lead of the lodes associated with gangue, at the present supplies being chiefly chalcopyrite and and occasional bornite. An exceedingly small proportion of green carbonate

* A Record of the Mines of South Australia, 1887–1890, opposite p. 26.

ore was found close to the surface, but a large proportion of the green ore was atacamite. The deposit did not extend more than a few inches, or occasionally a few feet, from the surface.

"The peculiarity of this cupriferous district was disclosed by the removal of these ores and the sinking of the shafts, and was that although the lodes continued regular, no further ore was met with; and, as a rule, no stain of copper was seen until the depth of 5 to 10 fathoms (30 to 60 feet) was reached, when rich oxides and malleable copper deposits were struck, and after that black and grey sulphides."

Mr. Brown states that five lodes occur in the Walleroo property, which is situated 10 miles north of Moonta Mine.

"The main lode is nearly vertical, although occasionally the underlay is a little to the north, and sometimes a little to the south. The lodes vary in width from 6 inches to 20 feet, and the ore they contain is chiefly chalcopyrite. As raised from the mine it varies from 3 to 10 per cent., with occasionally small quantities of rich ore." Country, talcose schist.

To Mr. L. G. Handcock, son of thewell-known late manager of these mines, the Writer is indebted for the following later particulars of these mines:—The lodes of Moonta vary in thickness from 3 to 8 feet, those of Walleroo up to 20 feet. The Moonta ore at the present time does not average more than about 2 per cent. of copper in the crude, but it can be dressed to a much higher grade than that of Walleroo, owing to the amount of pyrites in the latter, which, when cleanly concentrated, does not grade above 12 per cent.

The method of treatment at Moonta may be briefly described as typical of both. The ore is tipped on to a platform, where the attle or waste is picked out by boy-labour, a large percentage of the bulk thus being removed. The ore is then passed through rock-breakers and Cornish rolls. The screens average about five holes to the inch. The crushed ore is then jigged—water being obtained from the mine—and the "firsts" and "seconds" sent to the smelters, the tailings being discarded. Before, however, going to the jigs, the ore passes through agitators in which the coarse particles pass through the bottom holes, whilst the finer (slimes) are carried off by the current and over buddles. The concentrated slimes from the buddles are dried by spreading in the sun, and are subsequently charged in the furnaces with kiln-roasted ore.

The outputs of the Moonta and Walleroo Mines, which are now worked in conjunction, according to Mr. Brown, are as follows:—

Moonta Mine, from commencement to June, 1886—476,180 tons (of 21 cwt.), averaging when dressed 20 per cent. of copper; value in the colony, £4,579,097.

Walleroo Mine from commencement to December, 1886—451,016 tons (of 21 cwt.), averaging when dressed 10 per cent. of copper; value in the colony, £2,030,143.

The value of the production of both mines (60,259 tons of copper) from 1886 to 1897 inclusive, according to a return furnished by the Company, amounted to £3,153,839, and the total production of both mines to £9,763,079 (providing the output for 1886 has not been wholly or in part twice stated).

Burra Burra Copper Mine, according to Mr. Brown, was found by a shepherd in 1845, about 100 miles a little north of west from Adelaide, situated on bald hills standing 120 feet above the surrounding country. The prevailing rock is limestone. The ores obtained from this mine have been chiefly red oxide, and very rich blue and green carbonates. Native copper was also found. For many years the average yield was from 10,000 to 13,000 tons of ore, averaging from 22 to 23 per cent.

In Mr. Conigrave's "Handbook of South Australia," it is stated that during the twenty-nine years in which the mine was worked, the Company expended £2,241,167 in general expenses. The output of ore during the same period amounted to 234,648 tons, equal to 51,622 tons of copper. This, at the average price of copper, amounted to £4,749,224. The mine ceased working in 1877.

The following particulars are extracted from the Official Catalogue of the International Exhibition, London, 1851, at which ores from the mine were exhibited:—Mine started 5th September, 1845, with a capital of £12,320. To September, 1850, the following amounts of ore were raised:—

	Tons.	cwt.
September 30th, 1846	6,359	10
,, 30th, 1847	10,749	17
,, 30th, 1848	12,791	11
,, 30th, 1849	7,789	16
,, 30th, 1850	18,692	9
Total	56,428	2 in 5 years,

varying in quality from 30 to 70 per cent. The money value of the output was £738,108.

Prior to September, 1850, the ore was shipped to Swansea, but at the local smelting-works then established and at the mine 1,000 men were employed.

It is worthy of note that no calls were made after investment of the working capital—£12,320—and that the value of the original £5 shares rose to £200. The shares returned £40 per annum in dividends, a total of £800,000 being so paid. The mine was afterwards sold to a new company, but for many years has not been worked.

Mr. Brown describes the mine as follows:—"In the deeper levels regular lodes are met with, running north and south, containing very rich ore, malachite, red oxide, and grey sulphuret of copper; but above the 30-fathom level (180 feet) there is no appearance of lodes, the ores (malachite and azurite) being deposited with the greatest irregularity. The blue carbonate often occurred in round nodules, with crystals of the greatest regularity projecting from the surface. The malachite was found in the form of stalactite, in slabs encrusting fissures, and irregularly-shaped masses, which had been depositsd in cavities in the rocks. The country rocks are much broken and twisted, and consist of cherty siliceous rocks, crystalline white and gray limestone, blue slaty shales, and argillaceous sandstones."

Queensland Copper Mines.

Peak Downs Copper Mine was discovered in 1862, according to Mr. W. H. Rands, Assist. Government Geologist,* who stated that the lode could be "traced 1½ miles, running in an east and west direction. It has an underlie varying from 40° to 70° to the south.

"Country consists of foliated and contorted micaceous and hornblendic schists, dipping south-east. The outcrop is a gossan, consisting chiefly of

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* On the Geology and Mineral Deposits of the Country in the vicinity of Clermont. (Fol. Brisbane, 1886). Jack and Etheridge, Geol. and Pal. Queensland, 1892, p. 33.

red and brown hematite, with a little oxide of manganese and carbonates of copper. The ores were oxides and carbonates of copper to a depth of about 75 feet vertical from the surface, a mixture of oxidised ores and sulphurets to a depth of 120 feet, and below that depth they were ordinary sulphides of copper. The gossan at the surface was auriferous; assays of it gave from 4 dwt. to 1 oz. 16 dwt. of gold per ton, and also up to as high as 5 oz. of silver per ton.

"The deepest workings were 396 feet. Most of the lode was taken out to a depth of 240 feet for a distance of half a mile.

"From 1862 to 1878, when the original company was wound up, about 100,000 tons of ore, averaging 17 per cent., were smelted at the company's works, the value of which was £1,250,000."

Chillagoe.—Great results are anticipated from these very recently floated copper mines when the projected railway communication with the seaboard is established. *The lodes, according to Mr. R. L. Jack, Government Geologist of Queensland, occur as segregations or replacements of mechanically and chemically formed sedimentary rocks, also filling true fissures. The granite and porphyry of the neighbourhood also contain copper lodes. An important feature is the occurrence of silver and gold in the copper ores, which will probably have an important bearing on the metallurgical treatment to be adopted. The proximity of a large and easily available water-power in the Barron Falls will, as Mr. Jack points out, prove a potent factor in ensuring commercial success in connection with the latter.

Tasmania.

Mount Lyell Mine.—The following notes are extracted from a report made by Dr. E. D. Peters, jun., on the property of the Mount Lyell Mining and Railway Company (Ltd.) in 1893.

Dr. Peters' theory of the formation of the immense pyrites deposit of Mount Lyell is that the pyrites particles containing valuable metals, originally sparingly distributed through the older Silurian stratified rocks, gradually decomposed, and were carried away in solution by waters flowing into a lagoon or bog-hole. In contact with the organic acids always present in swampy waters the metals were precipitated in the state that they were originally in the rock, but in a massive, concentrated form. In time the pyrites filled the swamp-hole, and gradually became covered to a depth of hundreds of feet by the pebbles, sand and mud forming the now overlying conglomerates, slates, and schists. Subsequently the whole series became elevated and tilted into its present position.

According to this theory, the present width (300 feet) of the lode represents the depth of the original swamp-hole, and the direction of the present depth its longitudinal extension.

Mount Lyell is specially favoured by an abundant and easily-available water-power. Though the lode is a low-grade proposition, viewed as a whole, yet exceedingly rich bunches of ore occur, particularly closely adjacent to the mass of iron-stone (resulting from decomposition of pyrites) on the foot-wall side, yielding over 1,000 oz. of silver per ton and 20 per cent. of copper. The width of the lode at the time of the report was 300 feet, and the walls

* Bull. Geol. Survey Q'land, 1898, No. 9.

were diverging, Its length, so far traced, is 960 feet. The composition of the average ore, according to Dr. Peters, is as follows:—

Iron pyrites	83	per cent.
Copper pyrites	14	„
Heavy spar	2	„
Silica	1	„
	100	„

The average contents in valuable metals being:—

Copper	4·5 per cent.
Silver	3 oz. per ton.
Gold	2·5 dwt. per ton.

The freedom of the ore from silica is most remarkable. It contains from 45 to 50 per cent. of sulphur (33 per cent. is sufficient for pyritic smelting); 20 per cent. of quartzose flux is required for blast-furnace treatment.

Pyritic smelting was adopted at Mount Lyell, and soon the original breaking and roasting portion of the metallurgical scheme was abandoned, the ore being so suitable for the pyritic process that no preliminary treatment is found necessary. Just as it comes from the faces it is fed into the furnaces with the quartz flux, and about 5 per cent. of carbonaceous fuel. The first smelting produces a metal of about 20 per cent. grade, which is again subjected to the same treatment, and brought up to about 40 or 50 per cent., in which state it goes to the Bessemer converter, where it is brought up to about 95 per cent. copper.

Mansfeld Copper Deposit, Harz, Germany.

According to the authority quoted by J. A. Phillips and H. Louis*—

"Der Kupfershieferbergbau und der Hüttenbetrieb zur Verarbeitung der gewonnen Minern 1881," mining was commenced in the County of Mansfeld, on the southern declivity of the Harz, in the year 1199, and has, with but little interruption, continued flourishing up to the present time.

"In 1852 the various companies interested were consolidated into one (the Mansfelder Kupferschieferbauende Gewerkschaft) for working the Mansfeld copper schist, which now produces annually about 15,000 tons of copper, together with 75 tons of silver, and affords employment to nearly 13,000 miners. This was the first place where steam-power was applied to mining, in 1785 a Watts fire-engine being imported from England to keep down the water by driving the pumps in place of horse-power."

The strata of the Mansfeld copper district "form a comparatively regular basin, round the edge of which the copper schist crops out for the greater part of its circumference; its width is about 11 miles and its area about 193 square miles. Most of the present workings are restricted to the northern and western sides of the basin, where the copper schist occurs with a flat dip of from 5° to 8° over a length of about 14 miles."

"The bituminous marl constituting the copper schist, or copper shale, lies everywhere with the greatest regularity on the *Rothliegendes* [the formation forming the base of the Kupferschiefer or copper schist.—J.E.C.], so that it can be followed as a thin black band. [About 19 inches in thickness.—J.E.C.]

* J. A. Phillips and H. Louis. A Treatise on Ore Deposits, 1896, pp. 395–404.

"The metalliferous contents of the Kupferschiofer seam occur, as a rule, in the form of *Speise*, that is, sprinkled in the form of a very fine dust, which, on a tranverse fracture, causes a metallic reflection in sunlight. It has either a golden colour from the presence of copper pyrites in predominant quantity, or a violet, blue, and copper-red colour from the presence of erubescite; more rarely the colour is steel-grey from copper glance, or greyish-yellow from iron pyrites, and finally sometimes bluish-grey from the presence of galena. Although the speise principally consists of sulphuretted ores of copper, there also occur, in greater or less quantities not visible to the eye, sulphide of silver, blende, galena, iron and copper pyrites, copper nickel, and arsenical cobalt, as well as compounds of manganese, molybdenum, and selenium; oxidised compounds and salts also occur as secondary products.

"The term *Flotz*, seam, is usually applied to the productive bed only, the thickness of which varies from 2½ to 5 inches."

The roof boing softer than the floor is removed to a height of 16 to 22 inches, sufficient only to allow of the width of the workmen's shoulders as they work reclining.

The following analysis of the copper shale in 1879 is taken from the work quoted for comparison with that given by Professor David from the cupriferous shales of the Triasic Series of this Colony:—

Analysis of the Mansfeld Kupferschiefer (average from three shafts).

Silica	33·59	The Kupferschiefer of the Mansfeld District contains on an average from 2 to 3 per cent. of copper, with about 10 lb. of silver to the ton of copper.
Alumina	13·53	
Lime	12·63	
Magnesia	2·70	
Carbonic acid	8 97	
Iron	2 63	
Copper	2·59	
Silver	0·017	
Sulphur	3·43	
Bitumen by loss	13·91	

(Zinc, lead, manganese, nickel and cobalt not quantitatively estimated.)

Spain.

Rio Tinto and Tharsis Pyrites Deposits.—The following description of the Rio Tinto Deposits by J. A. Phillips and Henry Louis* applies closely to both mines:—"These deposits of cupriferous pyrites consist of a series of more or less continuous lenticular masses running parallel with the bedding of the enclosing slate, sometimes extending to a great length, occasionally having a width exceeding 50 fathoms, and composed of an intimate admixture of iron pyrites with a little copper pyrites, through which strings of the latter mineral sometimes ramify. Small strings of black sulphide of copper less frequently traverse the mass.

"The deposits are developed in the immediate neighbourhood of a series of dykes of porphyry that traverse the stratified rocks, and with the presence of which that of the deposits is evidently very closely connected.

"The Rio Tinto Company's (Limited) property is situated in the Province of Huelva, in the south of Spain. The amount of ore extracted in 1897 reached 1,388,026 tons, averaging 2·81 per cent. of copper. The Company possesses immense deposits of low-grade pyrites, and it is estimated that at the present rate of production—as above—it has seventy years output in sight.

"About 200,000 tons only can be calcined at the mines annually under the terms of concession. About 550,000 tons are exported; the remainder is

* A Treatise on Ore Deposits, 1896, pp. 499–500.

thrown on the reserve heaps, where it is spread over a large surface and drenched with water. This and the rainfall leaches out the soluble copper sulphate produced by oxidation or decomposition of the pyrites. The cupriferous solution is collected in pools and the copper precipitated with scrap-iron."

. . .

United States.

Lake Superior and Montana Copper Deposits.

The Lake Superior copper deposits consist of two lava-flows with interbedded conglomerates. Dr. M. E. Wadsworth, President of the Michigan College of Mines, Houghton, Michigan, states* that the copper deposits occur as—

"1. Vein-deposits (fissure veins).
"3. Flow-deposits (melaphyrs or amygdaloids).
"3. Bed-deposits (conglomerates).

"In the veins the copper is found intimately mixed with the gangue, or in sheets or irregular masses. In sheet form the copper extends downward, or has its sides approximately parallel with the vein. Often the vein is divided, and holds between its parts some of the gangue or melaphyr. . . . The melaphyrs themselves are often impregnated with copper adjacent to the veins. Good illustrations of the veins can be seen at the Phœnix, Cliff, Central Copper Falls, and other mines in Keweenaw County.

"In the vicinity of Hancock, Houghton, and Opechee some of the old lavas are mined. As stated before, these old lava-flows which now form melaphyrs (amygdaloids) have been greatly acted upon by water, and have had deposited in their mass different minerals associated with more or less copper. The copper is generally deposited in an irregular manner in the melaphyr, forming strings, globules, irregular masses, &c. These deposits are not in the form of veins, but are impregnations of old lava-flows, and hence are in the form of beds. As an example of mines worked upon these old lava-flows, there may be cited the Quincy, Franklin, Osceola, Atlantic, Huron, and the Copper Falls in part. . . .

"Besides the veins and lava-flows, the conglomerates have also been found in places to have had their interstices filled in with copper and other minerals. In them the old cementing mud, and oftentimes the pebbles of melaphyr, have been removed by percolating waters, and their places filled with copper, which penetrates even the minute cracks in the hard rhyolite (quartz porphyry) pebbles. These old sea-beach conglomerates are now worked in the Calumet and Hecla, the Tamarack, the Allouez, and other mines.

"The conglomerates are known to be old sea-beach deposits, like those that are now forming along the lake or ocean at the present time. This is proved by the rounded and waterworn character of their pebbles and grains; by the observed water-action on the surface of the underlying lava-flow; and by the fact that at their base the conglomerates contain considerable basaltic mud and pebbles derived from the underlying lava, both of which diminish in amount or are entirely wanting as the distance from the underlying trap increases.

"That the copper was deposited from water, with or without electro-chemical action, is shown by the fact of its being found enclosed entirely in minerals known to be formed by water only; also by its enclosing such minerals; by its being found in disconnected or isolated masses in the lavas and

* "The Origin and Mode of Occurrence of the Lake Superior Copper Deposits." Trans. American Inst. Mining Engineers, 1898, XXVII, pp. 667-696.

elsewhere; and by its greater abundance where there are to be seen the most signs of water-action. Had the copper been deposited by igneous agencies subsequently to the formation of the melaphyr and conglomerates it would have had a channel or line of passage, and would have been continuous along that line, so that all the different masses of copper would have been connected downwards, unless separated by fractures or faults. . . . From the fact that the copper is generally found most abundantly under the heavy lava-flows, and associated with minerals evidently the product of the decomposed lava, it appears probable that the copper was once finely disseminated through the lavas, and has since been concentrated by waters percolating through them. This view is advocated by Müller, Bauermann, Marvine, and myself, while a similar view has been advanced by S. F. Emmons to account for the origin and concentration of the Leadville ore-deposits.

"That the copper ore was deposited after the copper-bearing series was complete, is shown by the fact that it is found in fissures extending across the beds that could only have been produced after the beds were in place; by the fact that the copper was deposited subsequently to the jointing of the lavas, owing to its now being found wrapped around pieces formed by jointing; and by the extension of the copper from one flow down into another as a continuous mass.

"The means by which the copper was concentrated and deposited as native copper, instead of occurring in the form of the usual copper ores, is an interesting and, as yet, unsolved problem. . . . .

"The structure of Keweenaw Point may then be summarised as follows:—A deposit of sandstone overlain by lava-flows mingled with more or less of interbedded conglomerates, and finally overlain by sandstones. Subsequently, these beds suffered longitudinal and crossfracturing and faulting. Later, all were acted upon by percolating waters—both hot and cold—by which the rocks were altered to a greater or less extent, and the copper was concentrated and stored up in the conglomerates, lavas, and veins, in which it is now found."

The greater proportion of the Lake Superior copper comes from the conglomerate beds, which, according to Dr. Peters,* in 1893, amounted to 75 per cent. of an output of 85,662,000 lb. (38,241½ tons). This large proportion comes from an ore chute about 3 miles in length, and penetrated to nearly 4,000 feet in depth, worked by the Calumet and Hecla, Tamarack, and Atlantic Mines. According to the *Australian Mining Standard* of April 12th, 1899, the dividends paid by the first-mentioned mine to the end of 1898, amounted to $55,850,000, equal to over £11,000,000.

The grade of the ore is stated to range from ¾ to 1 per cent. of copper to about 1½ per cent., save in the case of the Calumet and Hecla, whose richness, 4½ per cent., makes it an extraordinary exception.† The average contents of the ores now mined at Lake Superior may be placed at about 2·9 per cent.‡

It must be pointed out with reference to the successful exploitation of these low-grade deposits that the copper of Lake Superior occurs in the metallic state, which obviates the costly processes of roasting and smelting. Simple concentration alone being requisite to prepare the metal for a simple fusion and refining process. The remarkable freedom of the native metal of this region from deleterious impurities renders it naturally of the highest market grade.

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* Modern Copper Smelting, 9th ed., 1898, p. 17. † *Ibid.*, 5th ed., p. 9. ‡ *Ibid.*, 9th ed., 1898, p. 17.

Copper Lodes of Butte City, Montana, U.S.

The following description of the occurrence of the Butte lodes is extracted from a paper by Dr. E. D. Peters, junior.* The metalliferous area of interest to miners is enclosed within a rectangle of $2\frac{1}{2}$ miles by 1 mile. The lodes are described as true fissures in granite, in which felspar is limited:—

"The copper lodes usually appear on the surface as wide bands of quartzose rock, much decomposed and heavily stained with oxides of iron. Carbonates and oxides of copper mostly appear only as stains, so that, as will be seen, there being little indication of the immense value below. This surface ore invariably carries silver, generally in a free milling condition, and in most of the larger veins in sufficient quantities to pay for treatment. In fact, nearly all the mines that are now considered distinctly as copper leads were first treated exclusively as silver properties—assaying from 10 to 60 oz. per ton, and averaging perhaps 20 oz. Perhaps the most noticeable feature of the Butte copper veins is their great size and remarkable continuity."

In the ninth edition of his work,† Dr. Peters gives the following description of these important lodes:—

"The ore occurs in irregular lodes in the granite, having an east and west strike, and an average dip of some 12 degrees to the south from the vertical, though in places this becomes as much as 45 degrees. The distribution of the ore is also very irregular, extensive bodies of the same being frequently found on breaking through what appears to be a well-defined wall. Again, there will be no definite line between the vein and the adjacent country rock. [These features are common also to several New South Wales lodes.—J.E.C.] The ore is usually found in chutes that often extend for several hundred feet along the strike before pinching out. Their depth is frequently even greater than their length, though they are sometimes broken by small faults.

"The veins are rarely banded, and vary in size from a few inches of compact ore up to 100 feet or more, as in the Anaconda Mine. Five or six feet may be regarded as the ordinary width, though a large proportion of the ore raised in Butte comes from stopes of much greater width than this. The gangue rock is usually granular and siliceous, but not quartzose.

"The croppings of the copper veins are moderately prominent, and consist of the usual brownish, iron-stained quartz that may be found at almost any point in the great American Mountain Chain [Rocky Mountains and Andes.—J.E.C.] from Alaska to Patagonia. Just below the surface, red and yellow oxides of iron appear, carrying high values in silver and gold, but usually low in copper.

"These decomposed ores extend to the water-level, which is reached at a depth of from 40 to 300 feet, depending upon the surface irregularities. At this point begins the zone of rich secondary copper ores that have made Butte famous. The copper minerals of this zone are difficult to determine, as they pass through all gradations from pure chalcocite down to chalcopyrite, bornite being also of very frequent occurrence. Iron pyrites is usually present in considerable amounts.

"Naturally, these rich, secondary ores have fallen off in depth, Ledoux estimating their average decline at 2 per cent. copper per 100 feet. But this diminution lessens as greater depth is gained, and the ore raised from the Butte mines at present, omitting a few bonanza bodies, averages about $6\frac{1}{4}$ per cent. of copper and 5 oz. of silver to the ton of 2,000 lb. (0·017

* U.S. Geol. Survey, Mineral Resources, 1883-84, pp. 374-396. † Modern Copper Smelting, 1898, pp. 18-21.

per cent. silver). There is a loss of some 18 per cent. in concentration, and to this must be added the smelting loss, which will reduce the yield of the great bulk of the Butte ores to 5 per cent. copper and 4 oz. (0·014 per cent.) silver.

"Notwithstanding this great decline in percentage and values (which, to be sure, has resulted partly from the ability to work lower-grade ores to advantage) the Butte mines are making more profit to-day from a 6 per cent. ore than formerly from one of double this richness. This results from the consolidation of mining properties, and from the astounding and radical improvements made in the metallurgical treatment of the ore. The rich surface ores of the district have furnished the capital that was needed to design and construct the improved plants, and to gain experience necessary for treating the lower-grade ores at a profit."

Below the rich secondary ores of Butte the ordinary yellow sulphide—chalcopyrite—has made its appearance. The grade of the ore sent to the Anaconda Company's smelters now equals 4·64 per cent. of copper, and 4·16 oz. of silver and 0·014 oz. of gold per ton.*

The following notes made during a visit of inspection to the Butte mines by the Writer in January, 1894, will perhaps be of interest:—

Montana Ore-producing Company.

Average value of ores about 7 per cent. copper, concentrated through sizing machines and Harz jigs. Ore calcined in O'Hara roasting furnaces, about 3 to 6 per cent. sulphur remaining in roast. Fed in charges of 8,000 lb. into reverberatory furnaces; product—matte containing 55 per cent. copper. Matte Bessemerised in converters in 3,000 to 8,000 lb. charges; brought up to 99—99·8 per cent. blister copper in from twenty to eighty minutes.

Butte and Boston Smelting Company.

Best ore from mine sent direct to smelters, other ore concentrated by Harz jigs and Frue vanners, and roasted in O'Hara roasting furnaces in preference to revolving cylindrical furnaces; smelting by water-jacket blast furnaces and reverberatories, former preferred. No flux used; ore consists of bornite, enargite, and pyrite, containing over 40 per cent. of sulphur. Basic slag formed. Matte sent to Great Falls for further treatment, where water-power is available. Copper refined by electrolysis.

The Parrott Smelting Works, Butte.

Ore, consisting of bornite and pyrite, averages about 4½ per cent. of copper. Part roasted in stalls; concentrates from Harz jigs and Frue vanners roasted in an improved Spence furnace. No fuel used after first firing, the sulphur in the ore forming the combustible.

The improved roasting plant consists of two furnaces built side by side, each containing six hearths, one above the other; between them is an iron framework with carriers running on rails, each being level with a hearth. The carriers are worked by a hydraulic press and belting on narrow drums. The carriers are fitted with rakes or ploughs extending into each furnace, which, as they travel in one direction, turn the ore on the hearths, and then return and take a fresh horizontal position so as to catch the ore between the furrows made in the previous trip.

* Mineral Industry, 1898, VI, p. 212.

The ore is fed from a hopper on to the top hearth, and there dried by the ascending heat. As the ploughs or rakes move to the end of the hearth, they scrape a portion of the ore into an opening, through which it falls on to the second hearth, and so on is transferred to each hearth in succession, meeting in its descent greater heat. The necessary firing is communicated from a small furnace at one end of each roaster. The capacity is stated to be about 50 tons per twenty-four hours, and all work is automatic, the roasted ore being raked by the carriers from the lowest hearths into trucks.

The slag from the smelting furnaces is removed by granulation in a stream of water, which transports it to the slag dumps. When required, the slag is moulded for building purposes; all the walls, floors, stalls, &c., being constructed of this material.

The ore is smelted without flux; being siliceous in some parts of the mine, it is mixed so that a slag with about 40 per cent. of silica is obtained. The matte is converted into blister copper (99 per cent.) by Bessemer converters.

The converters—three in number—when first charged, hold perhaps about 1 ton of the molten matte from the cupola furnace; but as the lining is eaten away the charge increases to about 4 tons. Each charge requires about one and a half hours to reduce to metallic copper. After the flame from the converter becomes clear, the slag—iron oxide—is poured off, and the remaining copper sub-sulphide is further blown upon uutil the required purity is reached by elimination of the remaining sulphur.

The copper is further treated at Great Falls—electrolytically—for separation of the contained silver (which in the ore averages about 6 oz. per ton).

The converter lining lasts about twelve hours, and consists of a mixture of silica and plastic clay, ground up and mixed together in proportions suited to the different portions of the converters.

All the flue-dust and slimes are smelted in reverberatory furnaces.

Anaconda Copper Mining and Smelting Company's Reducing Works at Anaconda.

The Company possess two large reducing plants of a total capacity of 14,000 tons of copper per month. The Anaconda plant is most advantageously situated to allow of transfer by gravity from the different treating floors. The ore brought by rail from the company's mine at Butte is first crushed by steam stamps of a capacity of 300 tons each per twenty-four hours. The crushed material then passes through a series of Harz and Cullen jigs, of succeeding fineness of gratings or screens. The slimes pass on to circular tables—buddles—about three sets, one below the other, the last stage being to allow the slime-water to pass into settling vats, from which the finest and lightest particles are carried over into large settling tanks. When these have settled, the water is drawn off, and the surface of the muddy slimes is covered with about 6 inches of lime, which absorbs sufficient of the moisture to covert the whole into the consistency of mortar, in which state it can be handled readily.

The concentrates are conveyed wet to the roasting house, in which ninety-six Brückner cylindrical revolving furnaces of a capacity of about 16 tons each are in operation. Each charge requires about twenty-four hours to roast, this being done with wood. The calcined ore is then charged into reverberatory furnaces—no blast furnaces being used—the resulting matte is converted into blister copper in Bessemer converters, and about 10 per cent. of the product passed to the electrolytic department, which was not open to inspection.

Descriptive Register of New South Wales Copper Mines and Occurrences, Alphabetically Arranged.*

Abbreviations.

A.—Albert Mining District.
B.—Bathurst Mining District.
C.—Cobar Mining District.
C. and R.—Clarence & Richmond Mining District.
H. & M.—Hunter and Macleay Mining District.
L.—Lachlan Mining District.
M.—Mudgee Mining District.
N. E.—New England Mining District.
P. & U.—Peel and Uralla Mining District.
S.—Southern Mining District.
T. & A.—Tumut and Adelong Mining District.
T. & T.—Tambaroora and Turon Mining District.
Dn.—Mining Division.

Notes.

(*a*) Unless otherwise specified the assays and analyses herein quoted have all been made in the laboratory of the Department of Mines and Agriculture, under the supervision of Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer.

(*b*) The registered numbers of assays or analyses are given over the year in which they were made, for example, $\frac{240}{98}$.

(*c*) Official reports quoted will be found in the Annual Reports of the Department of Mines and Agriculture on the pages given under the year of issue, viz., $\frac{1898}{\text{p. }60}$.

(*d*) The various copper occurrences can be located in a comparatively small area by reference to the Mining Divisions on the accompanying map.

Abercrombie, B., Trunkey Dn.—Copper ores are sparingly distributed in the ranges forming the watershed of the Abercrombie River.

Adaminaby, T. & A., Cooma Dn.—Samples submitted to the Department of Mines in 1897 yielded: No. 4,394—Copper, 6·32 per cent.; lead, 15·08 per cent.; silver, 3 oz. 19 dwt. 11 grs. per ton. No. 4,407—Copper, 24 per cent.

A copper lode was discovered in this locality about twenty years ago on Reynold's Kyloe Estate, about two miles southerly from Adaminaby. According to Mr. J. R. Maccue, of Cooma, the lode is 16 feet wide at surface, and has been opened to a depth of 80 feet. Two tons of ore dispatched are reported to have yielded 15 per cent. of copper. It has recently been reopened.

Adelong, L., Adelong Dn. (*See* Snowball Copper Mine.)—Copper pyrites are associated with the ordinary iron pyrites in the auriferous quartz reefs of the Adelong Gold-field.

A sample of copper ore submitted in 1897 from a locality five miles from Adelong, No. 2,492, yielded 10·98 per cent. of copper.

* Additions to this Register are invited from persons cognizant of occurrences not herein recorded.—J.E.C.

Adjungbilly Creek, T. & A., Tumut Dn.—Copper ores occur sparingly in the serpentine belt which trends from Muttama south-easterly to Lac-mac-lac and beyond. Adjungbilly Creek crosses this belt just south of Mt. Lightning, near the Murrumbidgee River. In Tea-tree Gully, about three-quarters of a mile south of the creek, native copper has been found. On the north fall of Mt. Lightning copper ores outcropped, but a few feet of sinking revealed the superficial character of the carbonate stainings. At Brungle, Wyangle, and near Kangaroo Mt., in the same belt, copper ores occur.

Albert Waterholes, L., Trundle Dn. Keenan and Party's discovery, one and a-half miles southerly from Albert Waterholes, twelve miles south-westerly from Dandaloo on the Bogan River, and forty from Trangie Railway Station, in the Parish of Albert, County Kennedy.

The following particulars have been supplied by Mining Surveyor R. H. Cambage. Country chiefly micaceous schist. Three mineral leases taken up. On M.L. 1, of 40 acres, a shaft has been sunk 25 feet on a quartz reef striking N. 75 degrees E., dipping almost vertically. In thickness it varies from 1 ft. to 2 ft. 6 in., and carries carbonates and grey ore. Five tons treated at the Smelting Company of Australia's Works, Dapto, for a satisfactory yield, which, however, is not stated. The following assays have been made:—$\frac{4152}{98}$ copper, 18·01 per cent.; gold, 10 dwts. 21 grs. per ton; silver, 15 dwts. 6 grs. per ton; $\frac{4471}{98}$ copper, 12·68 per cent.; $\frac{4404}{98}$ copper, 26·73 per cent. The reef is traceable into M.L. 2, of 25 acres., where a shaft has been started, but nothing of importance yet found.

On M.L. 3, of 38 acres, is a lode striking N.E, which has been opened to a shallow depth—7 feet at most—in several places. It carries chiefly grey ore, with a little carbonate. From a few inches at surface it widens to about a foot at 7 feet. Prospecting with encouraging indications is proceeding south of this lease.

Alecktown, L., Alecktown Dn.—Copper ores are reported from four miles W.S.W. of Alecktown, in the Peak Hill District. About six miles west, surface indications of copper ores, extending for some distance, were prospected, but proved only superficial.

Anaconda Proprietary Copper, Gold, and Silver Mine (formerly *Boone West Mine*), L., Condobolin Dn., about thirty miles northerly from Condobolin Railway Station, Parish Melrose, County Cunningham.

Under the name of Boone West, this mine was opened some fourteen years ago, but as far as prospecting then went, a payable lode was not revealed. After being abandoned for a number of years, it has been recently taken up and floated into a no-liability company of 70,000 shares, at 10s. each. Active operations were being carried on at the time of inspection, in October, 1898.

The country consists of ferruginous slate and much crushed conglomerate. At the surface, copper carbonates occur sparingly in the latter. A shaft has been sunk 100 feet deep on the west of the outcrop, and a crosscut driven to it. The ore channel now being followed at the junction of the conglomerate, on its southern course, is filled with soft chlorite with greasy headings. In places a little native copper appears, and thin films of red oxide in the jointings. A thin seam of pyrites occurs, but is almost, if not quite, free from copper sulphide. A little grey sulphide was found in sinking and driving, but not in quantity. Magnetic iron is present in bright micaceous particles, which may be confounded with copper glance. No payable ore had been exposed at the time of inspection along the southern drive at the 100-foot level, but the most favourable indications in the drive were to be followed in winzes as soon as the second shaft has been connected with the drive for ventilation.

Annandale Copper Mine, Blayney (formerly *Great Blayney Mine*). B., Blayney Dn.—This mine, at which operations have been recently renewed, is situated on a part of the Marsden Estate, close to the town of Blayney. The Blayney to Harden Railway line passes within a few yards of the mine, which possesses a private siding. The lode occurs in andesite, and is of considerable width. Over 2,000 tons of iron oxide are reported to have been quarried from the outcrop for the Lithgow Iron Smelting Works before any trace of copper was discovered.

In 1881 traces of copper ore were exposed in a small quartz vein. In following it down a little copper ore was met at 90 feet from the surface. The mine was then taken on trial by Sydney investors, and subsequently purchased by them for £10,000.

The Great Blayney Copper Mining Company was then formed (in 1882), and smelting works erected. At 110 feet the lode was proved 40 feet wide. The deepest shaft was sunk nearly 300 feet. Unfortunately, particulars of the early operations are not obtainable; work was, however, not continued for any length of time.

In 1889, under the name of the Annandale, the mine was again worked with reported fair results, the company operating being a small one. A furnace was erected at this time, according to the local Mining Registrar, on a new principle, which, however, was unsuccessful, and another had to be erected in its place. At this date several shafts had been sunk on the lode, ranging from 110 to 292 feet, well prospecting the lode to that depth. Six tons of copper were produced, realising £57 10s. per ton.

In 1891 it was reported that the mine was shut down, owing to the low price of copper and the low grade of the ore.

In 1892, 10 tons of copper were produced, valued at £435.

The mine then remained idle until 1897, when it was again taken up by a syndicate, who began unwatering it. After nearly twelve months' baling by kibble, the water was lowered sufficiently to allow of ore being stoped at the 90-foot level for trial smeltings. The ore from this level—just below the zone of oxidation—consists of magnetic iron pyrites and chalcopyrite, which was roasted slightly in heaps and then smelted in reverberatories without flux, as a fair percentage of lime (calcite) occurs in the ore.

The magnetic pyrites (pyrrhotite) possesses the deceptive appearance of flesh-coloured copper sulphide, and this resemblance is apt to give an inflated idea of its true value. A massive sample of the mineral was tested in the Departmental laboratory for gold, silver, and nickel, but none of these metals were detected; copper was only present to the extent of 0·22 per cent. The curious fact that pyrrhotite, though often rich in copper pyrites and nickel, rarely carries more than traces of the precious metals has already been mentioned in this work.

Smelting operations were begun in 1898 in two reverberatory furnaces erected by the previous company, the second consignment of copper being dispatched in May.

In July it was announced that a public company had been formed with a capital of £100,000, and that two water-jacket blast furnaces were to be erected.

The mine was visited in June and December of 1898. At the first date the 90-foot level of one shaft only was open for inspection. The walls and surfaces of the old workings were glistening with copper sulphate and in some places with fine crystals of native copper deposited from solution during the submergence of the workings.

In December no fresh features had been developed in the mine, active operations so far as stoping and smelting were concerned having ceased pending the erection of the new haulage, pumping, and smelting plants. The two first were already nearing completion, and the foundations were being prepared for the latter.

A shaft (180 feet deep) in the east wall of the lode, started by the previous owners, has been converted into the main shaft of the new company; substantial poppet-heads being erected, whilst prospecting operations proceeded by means of a small portable engine. A crosscut then being driven from the 180-foot level had already pierced 30 feet of lodestuff, according to Captain Cock.

There is little question that such of the lodestuff as has been exposed at the 90-foot level is suitable for blast-furnace treatment at a low cost, the grade, however, is undeniably very low. If, as is surmised, the ore is of a kindly smelting nature, it behoves the proprietary to ascertain the amount of siliceous flux—if any—that it can safely absorb, and if appreciable to endeavour to secure gold and silver bearing ores for the purpose. If the Blayney lode should prove a great fluxing base—like Cobar—the natural poverty of the ore would be counterbalanced by the possibilities opened up for spirited enterprise in connection with siliceous, refractory, and low-grade gold and silver ores of the surrounding mining districts approachable by rail. It might also be the means of opening up the old copper lodes around Byng and Lewis Ponds, some of which would probably afford remunerative employment for small parties, if the dressed ore could be disposed of in the district.

The numerous small copper veins and lodes of the Carcoar and Woodstock Districts might also profit by the erection of a central smelting plant at Blayney.

Annandale South Copper Mine, M.L. 1, B., Blayney Dn.—Held by Messrs. Clutten and Shearer. First opened about three years ago under aid from the Prospecting Vote. At 80 feet carbonate of copper occurred. Shaft continued to 150 feet. Lode about 1 foot wide. Two or 3 tons of ore raised; picked samples reported to have yielded from 24 to 60 per cent. of copper.

About 10 chains S. 20° E. of the above, another shaft has recently been sunk about 40 feet on a quartz reef carrying copper and iron pyrites; the former apparently increasing in proportion with depth. The oxidised ore at surface is reported to prospect about 8 dwts. of gold per ton; the sulphide about 8 per cent. of copper. The reef strikes N. 70° W. in andesite, and dips S. 70° W. Thickness at 40 feet, about 1 ft. 6 in.

Appleton Copper Mine, S., Goulburn Dn.—Under this name a lease was taken up and prospected; but as no payable lode was discovered the enterprise was soon abandoned.

Apsley Copper Mine, B., Rockley Dn.—The earliest reference to this mine is contained in the "Mineral Statistics of New South Wales," 1875, p. 92. At that date it had been proved to a depth of 100 feet. Thickness of lode 3 feet to 5 feet. Strike north and south; dip easterly. Ore assaying from 4 to 18 per cent. of copper. 150 tons of ore were being raised monthly and disposed of to the Esk Smelting Company, which had a reverberatory furnace running intermittently near by, the sale tariff being 85s. per ton for 10 per cent. ore, and rising 13s. per unit. Eighteen men employed.

The yield in 1876 is given as 20 tons of copper.

In 1877 the lode was traced further to the north. Operations during 1878 were confined to near the surface for carbonate ores; and continued so for the better part of 1879. During the latter part 60 tons of ore were raised, yielding 7 tons 16 cwt. of copper, valued at £429. In 1880 the mine changed hands and continued in work without interruption. 191 tons of ore were raised and sold to the Bowenfells Smelting Works for £750.

In 1881 only 28 tons of ore were raised, producing $3\frac{1}{2}$ tons of copper, value £220. Lode 6 inches thick in a 40 feet shaft. In this year the mine was reopened by Mr. Lewis Lloyd; but no further particulars are available of the result of operations. For many years it remained idle. In 1898 it was restarted; and in December of that year it was visited by the Writer. A new shaft had been sunk 186 feet, crosscut east 30 feet to the lode on which a winze was sunk 63 feet following the slight underlay to the east; the course of the lode being about N. 20° E. At the bottom of the winze the lode was solid and about 9 feet thick. Hanging wall well defined, foot wall broken. Lodestuff largely blende with chalcopyrite and pyrite. The ore raised during these prospecting operations is broken and sorted into "firsts," "seconds," and "wasto," the "firsts" being dispatched to Mr. L. Lloyd's Smelting Works, at Lithgow; 38 tons have yielded 7 per cent of copper. A sample, $\frac{1302}{98}$, yielded 7·93 per cent. copper; 16·53 per cent. zinc; and 2 oz. 7 dwt. 22 grs. of silver per ton. No gold. Country schist, partly hornblendic.

Arable Station, T. and A., Cooma Dn., 13 miles S.W. of Cooma.—About one mile from the old Arable Station, Mr. G. F. Litchfield, of Matong, states that two small outcrops of copper ore occur in slate country having a north and south strike. Several assays made by the above yielded from 20 to 70 per cent. of copper. Later a shaft was sunk in one of the most southern outcrops to about 30 feet, but the result is not known.

Armstrong Copper Mine, L., Molong Dn., Parish Yetholme, County Bathurst—In the Mineral Statistics of New South Wales, 1875, p. 92, it is recorded that a company was engaged working the above mine, and the following particulars are given:—Strike of lode, E. and W.; dip slightly north; thickness at surface, 2 feet, gradually increasing to 4 ft. 6 in. at 50 feet. The ores consisted of red and black oxides, carbonates, and sulphides, assays of which yielded from 15 to 36 per cent. of copper; 60 or 70 tons of ore were then at grass. The intention of erecting smelting works on a new American principle was expressed. No further particulars of this mine are recorded, at least not under its original name.

Arramagong, L., Grenfell Dn.—In 1890 Mr. W. Anderson, Geological Surveyor, recorded the presence of blue and green carbonates of copper in the argentiferous lead lode opened by the Great Southern Silver Mining Company, in C.P. 17, Parish Tyagong, County Monteagle, between Young and Grenfell. A small quantity of silver-lead ore was raised, but operations were soon abandoned.

Arrowsmith Mount, A., Milparinka Dn., County Evelyn.—The presence of copper ores have been noted in this locality.

Babindah, C., Nymagee Dn.—Copper ores occur nine miles from Nymagee, towards the Bogan River, in Parish Babindah, County Flinders.

Backes's Copper Mine, M., Wellington Dn.—Leases for copper were taken up about 1873 by John Backes, at Sugarloaf, Parish Galwadgery, east of Wellington. In $\frac{1883}{p.\ 61}$, the Warden described the mine as situated east of The Springs Railway Station, near the Burrandong Road. At this time it was designated the Great Burril Mining Company's Lease. One of the proprietors, C. Barton, supplied the Warden with the following information:—Three shafts, over 100 feet each, have been sunk, also a number of shallower ones. The first shaft was on a vein rather inconstant in thickness, sometimes pinching out, the maximum thickness being 2 feet; about 25 tons of ore were taken from it, averaging about 12 per cent. copper. Another shaft, sunk at the north end of a large gossan outcrop, reached a deposit of copper and iron pyrites. A drive to the eastward, at 60 feet, discovered a small quantity of decomposed lodestuff, containing native copper. Assays of ore then at grass were reported to yield 8 to 14 oz. of silver per ton, and from 4 to 7 per cent. of copper. The principal feature of the property was reported to be an immense gossan "blow," or outcrop.

Back Creek Station, near Kimo, L., Gundagai Dn.—A copper lode was opened in this locality by Engellen and others, of Gundagai. At surface about 1 ft. 6 in. thick of good ore, bornite, occurred. A shaft was sunk 50 feet, but the ore pinched out at that level.

Badjerrigadu Mountain, near Corona, A.—The Mining Registrar reported payable copper ore from this locality in 1890, which caused a considerable area to be taken up, but apparently without development of any permanent deposits, as there are no further references.

Badja River, Monaro.—Under this name a sample of carbonate ore was submitted to the Department in 1894, No. 1,642, which yielded 21·94 per cent. of copper.

Balaklava Iron and Copper Mine, A., Broken Hill Dn., south of Rockwall Paddock, about 10 miles S.S.W. from Broken Hill.—Copper ore was first worked here in 1887 by a company bearing the title of the Balaklava Iron and Copper Company, but operations were not extensive. In 1894 Mr. J. B. Jaquet, Geological Surveyor, reported on the ironstone and copper deposits in the following terms:—* "They consist of a series of well-defined parallel lodes, occurring in gneiss and schist. All the lodes dip west at a high angle. One of them, which has a width of 12 feet, can be traced nearly a mile, while others can be traced for several hundred yards. The ore consists of massive hematite, which, on account of its freedom from silica and other impurities, forms a valuable flux for silver-smelting, and large quantities have been used in the smelting works of Broken Hill. The hematite is associated with copper carbonate in some places, and it is possible that the points where the carbonates occur represent the outcrops of shoots of copper ore. No attempt has been made to prove these lodes below 50 feet. In view of the fact that so many of the rich copper deposits in the Australian Colonies and elsewhere are capped by masses of hematite, I would recommend these lodes being prospected to a depth of (say) 200 feet."

In 1896 it was reported that the Walleroo Copper-mining Company of South Australia was reopening this mine, and had applied for several adjoining leases. The trial was, however, soon abandoned.

Bald Hill, C., Cobar Dn., 30 miles N.W. of Byrock, and 50 miles N. of Cobar.—Copper ore is reported to occur here.

Bald Nob Mine, N.E., Emmaville Dn, about 5 miles north of Emmaville.—Native copper occurs in fluorspar at the 90-foot level in the Bald Nob Tin Mine. The most interesting feature of the occurrence is the association of tin and copper, the only other noted in the Colony being at Gumble, near

* Geology of the Broken Hill Silver Lode, p. 132.

Molong, though traces of copper ores are present in other of the New England tin lodes. Mr. J.B. Jaquet, Geological Surveyor, who visited the mine, states that the same conditions obtain at Bald Nob as in the Dolcoath Mine in Cornwall, where copper gave place to tin in the lower levels. At Bald Nob, for 30 feet from the surface, good copper ore was obtained; below this the lode became poor. At 70 feet, apparently where the diorite was entered in the shaft, tin ore came in in limited quantity in the form of a rich bunch. At 90 feet, in a drive easterly, native copper occurs in fluorspar, also a bunchy deposit, probably an impregnation along the junction of the sedimentary and intrusive rocks of which the country consists. The diorite in the vicinity of the shaft is impregnated with copper pyrites. A few tons of very rich copper ore have recently been obtained, but the tin ore is not yet in sufficient abundance to pay.

This mine was opened some twenty-five years ago to a shallow depth. In the present operations a shaft has been sunk 90 feet at the junction of diorite and claystone.

Barcoo Copper Mine, C., Gilgunnia Dn., Cowl Creek, near Gilgunnia.

Barraba, P. & U., Barraba Dn. (*See* Cornish Copper Mine.)—Two miles N.E. of Cornish Copper Mine in Parish Capel, County Murchison, carbonate of copper was discovered in October, 1898. Lode reported to be 6 feet wide. Strike N. and S., in quartzite. Aid granted from Prospecting Vote for development.

Barrier Range, A., Broken Hill Dn.—In addition to the Broken Hill line of lode, of which special mention is herein made, copper ores occur with silver and silver-lead ores in the following mines in the Barrier Range Silver Field, viz.:—War Dance, Red Flag, Silver King, Princess Midas, Copper Blow, Great Barrier, Balaklava, Diamond Jubilee, Lily, Augusta, Barrier Queen, &c.

Twelve miles N.E. of Mt. Gipps copper ores assayed in 1885 from 25 to 43 per cent. of copper.

From the Princess Midas Mine, Purnamoota, auriferous quartz and copper ores were exhibited at the Melbourne Centennial Exhibition, 1888, and similar lodestuff from the Red Jacket Mine.

In prospecting papers ($\frac{2202}{98}$), Mr. J. Hebbard, Inspector of Mines, reported on the Barrier Queen Copper Mine, which contains lead and silver in addition. Situated about twelve miles from Broken Hill, on the road to Thackaringa, in an easterly direction from the Pinnacle line. Lode two feet thick. Formation patchy. Aid granted for proving.

The Mining Registrar, in his report for 1898, states that two leases for copper were taken up on the Grasmere Holding in September, but that no work had been done.

In prospecting papers ($\frac{1312}{97}$), Mr. Hebbard reported on the Augusta Mine—M.L. 101, Parish Sentinel, County Yancowinna, twenty-three miles S.E. of Broken Hill. The following extract has been taken from the report:—"Lode traceable by its outcrop for 1½ miles. Lode material consists of heavily iron-stained quartzite, carrying copper and lead in discernible quantities, and well worthy prospecting. Previous efforts in early days of the field confined to deep vertical shafts without touching the lode."

Aid granted to sink from the bottom of an open quarry following the underlay. The lode hereabouts is 4 feet thick.

Aid has also been granted on Mr. Hebbard's report for driving at the 200-foot level in the Nine-mile Claim, six miles N.W. of Broken Hill, where a strong lode carrying zinc, lead, and copper ore occurs. The copper ore occurring on the west wall of the lode.

Broken Hill.
(Showing outcrop of lode.)

Lady Dorothy (formerly Euro) Mine, nine miles west of Broken Hill, in schist country. Two thin interbedded veins of copper are being tested under aid from the Prospecting Vote, pp. $\frac{2110}{99}$.

Barrier Silver and Copper Syndicate's Mine, A., Broken Hill Dn., M.L.'s 140, 141, and 146, Parish Bray, County Yancowinna, about three miles N.E. of Silverton. The following particulars of the Syndicate's property are extracted from a report in 1896 by Mr. Joel Phillips, Manager of Broken Hill Junction and Junction North Silver Mines:—"You have on your claims what appears to be a well-defined copper lode, that has been traced and worked upon in places for the full length of your property. On section 140 a shaft has been put down to a depth of 120 feet, following the underlie of the lode from the surface. The bearing of the lode is north 11° 30′ west, with a slight dip to the east. By sinking a few feet below the surface, large boulders of green carbonate of copper were met with, and a quantity of ore was broken and sold to the English and Australian Copper Company, Port Adelaide. At a depth of about 30 feet the green ore gave place to black and grey ores, intermixed with chalcopyrites and quartz. This class of ore was followed down to the present bottom of the shaft. A little stoping has been done near the bottom, some good parcels of ore having been raised. The lode now standing near the bottom of the shaft, I am informed, varies from 2 to 6 feet in thickness of a similar class to the above-mentioned. The ore when dressed averages about 30 per cent. of copper. The country rock is decomposed schist."

Baw Baw., S., Goulburn Dn.—Copper is reported from this locality.

Belara Copper Mine., M., Wellington Dn., about twenty-five miles from the Wellington Railway Station, alongside the main Mudgee Road. Locality also known as Goolma.

The Belara Mine, according to the Warden's report of $\frac{1880}{p. 98}$, was discovered by G. McDonald on freehold land. In the "Mineral Statistics of New South Wales," 1875, p. 90, the lode is recorded as 2 feet thick. Strike N. and S., dip 1 in 3. 150 tons of ore were then at grass, but no tests had been made.

The next official record is that of the Under Secretary for Mines in 1885, p. 31, in which it is stated that 1,000 tons of ore had been raised during the year, producing 640 tons of regulus, which is probably an error. Depth of shaft, 160 feet; deepest level, 140 feet. Width of lode, 8 inches to 8 feet.

In 1886 there was no record, but in $\frac{1887}{p. 72}$ the Mining Registrar reported that no smelting was done in 1887, but during the year just ended 1,400 tons of ore were raised, 840 of which were smelted for 70 tons of copper, valued at £5,250.

In 1889 little work was done. 300 tons of ore raised yielded 16 tons of copper, valued at £800. The smelting furnaces were only worked for three months, mostly experimenting with gossany gold and silver ores.

In 1890 the only work performed was the deepening of the engine shaft to 55 feet. The mine apparently remained idle from this date until October, 1893, when twenty men were employed until May, 1894. 200 tons of ore raised during this period yielded 9 tons of copper, valued at £336. No further work has taken place. So far as official returns are recorded from this mine, the output has been 2,050 tons of ore, from which 95 tons of copper were produced, valued at £6,386, and 640 (?) tons of regulus, of which the copper contents are not given.

Mr. D. H. Thomas, at one time head smelter, Girilambone Copper Mine, states that he and others had the mine on tribute in 1893 for about six months, during which about 20 tons of copper were produced (9 in the official return). To Mr. Thomas the Writer is indebted for the following particulars, which represent the mine as it now stands :—Shaft, 200 feet deep ; levels at 112 feet and 155 feet (lowest) ; lode, 3 feet wide at 112 feet, 6 feet at 155 feet. Value of ore—5 per cent. copper; gold, 3 dwt., and silver, 3 oz. per ton. Smelting plant at this time consisted of two reducing, one calcining, and one refining furnace. Firebrick made from clay, obtained about 9 miles distant. The lode is reported traceable on the surface for a considerable distance by a gossan cap from 1 ft. 6 in. to 12 feet wide, in which gold and silver are present. Carbonates of copper showing in lode 300 yards north of shaft. Gangue siliceous at surface. Sulphides from lowest level solid. Country consists of slate.

Bell River, L., Molong Dn.—In April, 1852, Mr. Stutchbury (first Government Geological Surveyor) mentioned copper lodes close to the Bell River, in the neighbourhood of Molong, having a thickness of 5 to 7 feet, which he regarded as well worthy investigation.

Belmore Copper Mine, near Cow Flat, B., Rockley Dn.—The earliest official record of this mine is that by the Mining Registrar in $\frac{1874}{\text{p. }60}$, to the effect that the mine was being worked by tributors with payable results. (Tributors were also at work on Messrs. Hulks & Co.'s property, two miles S.W. of Cow Flat, with advantage to themselves.) In this year it is also recorded that Messrs. Croaker & Co. erected a smelting furnace about one mile from the Cow Flat Mine, and rented it to the Esk Smelting Company ; this was probably identical with the furnace run by the latter near the Apsley Mine.

In 1877 payable sulphides were reported below the oxidised zone. In 1878 little work was being done, about 7 or 8 tons of ore per month only being raised. In this year the late Government Geologist, Mr. C. S. Wilkinson, visited the mine, and described the ore bodies as "small, irregular veins of copper ore in greenstone, at its junction with the Silurian Sedimentary Series." $\frac{1878}{\text{p. }160}$.

In 1879, 190 tons of ore were raised, and sold for £440. The ore at this time was reported to be too low grade for remunerative working at the low price of copper ruling.

In 1880, 172 tons of ore were raised, and sold for £317.

In 1881, 118½ tons of ore were raised, and sold for £163.

No further returns are obtainable. The deepest shaft is reported to have reached the 100-foot level.

On 28th April, 1898, the *Australian Mining Standard* reported that the mine had been taken over by the Anglo-Australian Exploration Company, which proposed to reopen and prospect it.

In June, 1899, aid was granted from the Prospecting Vote to cross-cut and drive at the lowest level attained.

Belmore Copper Mine, Woodstock, B., Cowra Dn.—This mine was discovered about 1867. The ore consisted of red oxide at surface from 6 to 12 inches thick. Eighty tons were sent to the Cadia Smelting Works (near Orange), averaging, undressed, 37 per cent., according to report. The mine was afterwards sold for £400. The new proprietors sank three shafts from 60 to 90 feet deep. Fifteen tons of rich red oxide, raised during operations, are reported to have averaged 64 per cent. at the Lithgow Smelting Works. The ore cut out in depth, but was making again, though much mixed with quartz.

Belmore Copper Mine, Quidong, Monaro, T. & A. & S., Delegate and Bombala Dns.—In an official report, dated 6th February, 1852, the Rev. W. B. Clarke wrote as follows of the site of this subsequently-opened mine*:—

"As the extent of the limestone country is considerable, and its aspect is such as to lead to the belief that it is metalliferous, being bare of grass and extremely ferruginous in hue, occasioned by the presence of cupriferous ironstone. I think it is not improbable that more than an insignificant amount of gold may be discovered hereafter, but the value of the locality appears to me to rest upon other considerations.

"Exactly where the largest auriferous hollows occurs, veins of copper and lead, several feet in width, make their appearance in the limestone, and pass through to the face of the cliff in a south-east direction. The veinstone is chiefly barytes, and the ores are chiefly fibrous and earthy green carbonates, and yellow and iridescent sulphurets of copper, with interspersed crystallised sulphurets of lead. The latter stands out of the face of the limestone in independent crystals.

"As copper and lead exist in various parts of this tract of country, it is extremely probable that a mining field may be here profitably worked."

In Mr. Clarke's collection at the Paris Exhibition of 1855 were specimens of copper and lead ores in limestone, from "Merinoo, Deleget River," which, doubtless, corresponds with the above locality.

In December, 1868, the prospectus of the Belmore Freehold Silver and Lead Mining Company, Bombala, was issued. Judging from the appearance of the locality when visited by the Writer in 1897, a considerable amount of prospecting for copper must have followed the formation of the company. A large amount of work was done in sinking and driving on the east side of the Quidong River, in country revealing surface indications of copper, and abundant oxide of iron, the latter resulting from oxidation of pyrites, which, in its unaltered condition, is very plentiful in the spoil from the deepest shafts. Another source of the prevalent iron oxide which colours the rocks and soil of the neighbourhood, is the original precipitation of iron salts by the abundant organic remains (Upper Silurian) in the strata, which consist of mudstone, sandstones, and limestone. The précipitates have been converted into oxides, as weathering and denudation exposed the fossiliferous layers to atmospheric influences. In some instances, Clarke's Rock, for example, the cellular, gossany appearance imparted to certain strata by the decomposition of the original organic remains, and the subsequent alteration of the investing salts into powdery oxides, has given rise to an erroneous impression that the "gossan"-like outcrops are caps of metallic lodes.

Evidently these early prospecting operations failed to reveal any workable copper lodes. Later a stamp battery and smelting furnace were established on the opposite side of the river in connection with the lead ores, but apparently were little used; it cannot, however, be said that the prospects of the field have been exhausted.

Belubula Copper Mine, B., Canowindra Dn., Portions 4 and 5, Parish Malongulli, County Bathurst, Licking Hole Creek, about sixteen miles from Canowindra.—The late Mr. W. M. Rothery, of Cliefden Station, informed the Writer that in 1845 or earlier copper ore was discovered outcropping on Portions 2 and 3, adjoining those abovementioned, but as nothing defined was found below the surface indications, attention was directed to the site of the above mine on Cliefden pre-emptive lease, and Portions 4 and 5 were

* Southern Gold-fields, 1860, p. 156.

purchased by Messrs. Want and Donaldson. Extensive prospecting operations were carried out, the main shaft reaching the 84-fathom (504 feet) level, and drives were extended at various levels. Mr. Rothery, who acted as paymaster for the proprietors, stated that absolutely nothing beyond traces of copper were ever discovered. Ores purporting to be from this mine according to the catalogue were exhibited at the Paris Exhibition of 1855.

Bethungra, L., Cootamundra Dn.—Copper ore is recorded from this locality.

Big Ben Copper Mine, Melrose, L., Condobolin Dn., about half a mile west of the Anaconda Mine.—As at the latter mine, the geological formation consists of slate and conglomerate, with the addition of quartzite. The mine is situated on the summit of a small hill, where a little copper-staining is visible. It was first discovered about fourteen years ago, and was prospected about the same time as the Anaconda—then the Boone West. Aid from the Prospecting Vote was granted to continue the prospecting shaft to the 120-foot level, and to crosscut west through the conglomerate. No payable ore was discovered during these operations. In the beginning of 1899 it was announced that a company had been formed to reopen this mine.

Binalong, L., Boorowa Dn.—Copper ores are recorded from near Binalong, and from six miles south, where a shaft was sunk 60 feet on the peak of a ridge, but a defined lode was not struck. About half a mile further south good indications are reported.

Binda, B., Tuena Dn.—Copper ores have been reported from between Binda and Mulgowrie.

Bindogandra ?.—A sample ($\frac{2310}{95}$) of copper ore from the "Miss Matteson Mine," twelve miles from Bindogandra, yielded 20·08 per cent. copper.

Bingara, P. & U., Bingara Dn. (*See* Bobby Whitlow, Prince of Wales, and Mitchell's Copper Mines).—Copper ores are also reported from the following localities in the district:—Harrison's Mine (which see), Upper Bingara; one and a half miles N.W. of Harrison's, copper ores occur in serpentine, as they also do at the head of Spring Gully, near Bingara. Carney's, Smith and Party's, and Horsfall's are also prospecting claims near Upper Bingara. A sample from five miles south of Lower Bingara ($\frac{1471}{98}$) yielded 25·29 per cent. of copper.

Bingara Mining Syndicate's Mine, about eighteen miles from the Cornish Copper Mine, Gulf Creek, near Barraba, P. & U., Bingara Dn.—The following parcels of ore from the mine were treated at the English and Australian Copper Smelting Works, Waratah, near Newcastle:—

1 ton	19 cwt.	yielded	44	per cent.	of copper.
2 „	12 „	„	40	„	„
7 „	5 „	„	34¼	„	„

Black Mountain, A., White Cliffs Dn.—Copper ores have been reported at Yungnulga, twenty-two miles N., and three miles N.E. of S.W. corner of county Yungnulga.

Black Mount.—(*See* Rockley.)

Black Range, L., Trundle Dn.—From Black Range, fifteen miles S.W. of Trundle, a sample of copper ore ($\frac{4114}{97}$) yielded 15·48 per cent. copper.

Blayney, B., Blayney Dn. (*See* Annandale, South Annandale, Wright and Osborne's, and Quigley's Hill Mines.)

On Stinson's property, west of the cemetery, a copper lode was opened about nine years ago to a depth of 60 feet, its thickness being 3 feet. About £300 worth of ore is reported to have been dispatched from this lode to the Lithgow Smelting Works.

On Glasson's properties, and Clauson's, close to Blayney, a little copper ore has also been discovered.

Blue Mountain Creek, P. & U., Walcha Dn.—Copper ores are reported from about 1¼ miles south of the creek and 19 miles N.E. of Walcha.

Bobadah, C., Bobadah Dn.—At the Overflow Silver Mine copper ore occurs in one of the shafts (Booth's) associated with gold, silver and lead. The lode strikes N. 30° W. in crushed porphyry; its chief value depends on the gold, silver, and lead contents, as the copper ores—carbonate and red oxide—are not very prominent.

Sullivan's lode, about one mile from Hillman's Tank, has been opened under aid from the Prospecting Vote, but no payable ore was discovered.

Copper ores also occur about one mile N. of the Walker's Hill Homestead, where aid was also granted with unfavourable results. (*See* also Yellow Mountain, and Recovery Copper Mines.)

Bobby Whitlow Copper Mine, P. & U., Bingara Dn., six miles east of Bingara, opened about 1879–80.—This mine has recently been taken up by Messrs. Stevenson, Jennings and Party, the water taken out and the shaft retimbered preliminary to further development. Mr. Stevenson, has kindly supplied the following particulars of this mine, which has long been idle. The shaft is reported to be 110 feet deep, with levels at 50 and 70 feet, driven 18 and 33 feet respectively. The lode varies from 1 ft. 6 in. to 1 ft. 10 in. thickness in the shaft and drives. About 70 tons of ore are reported to have been dispatched during operations. The following samples have recently been submitted for assay by the present proprietary:—

$\frac{3228}{98}$ Copper gossan, depth 12 feet—Yield, copper, 33·83 per cent.	Gold, 4 dwt. 8 grs. per ton. Silver, 18 dwt. 12 grs. per ton.
$\frac{2232}{98}$ Massive sulphides, copper and iron, depth 12 to 70 feet—Yield, copper, 17·82 per cent.	Gold, 8 dwt. 6 grs. per ton. Silver, 8 dwt. 17 grs. per ton.

If the present operations should result in opening workable copper deposits, the amount of gold concentrated in the matte or refined copper from the lower grade copper ores should be of commercial importance.

Bocoble, M., Gulgong Dn.—In 1880 the Warden reported a lode of grey ore at Bocoble, 3 feet wide, between well-defined walls. Assays of 17 per cent. copper, and 1 oz. 9 dwt. of gold, and 7 oz. of silver per ton were mentioned as being made from it. Carbonate and gossany ores were also reported to occur in the neighbourhood.

Bolivia, N. E., Emmaville Dn.—Copper and arsenical pyrites from Bolivia yielded, $\frac{12}{88}$, copper, 15·91 per cent.; silver, 21 oz. 3 dwt. per ton.

Bombala, S., Bombala Dn.—On C. Garnock's property, Gallagher's Plains, eight miles northerly from Bombala, a copper lode occurs having a reported width of 8 feet at surface. A sample assayed 10 per cent. copper, and 5 dwt. of gold, and 1 oz. 17 dwt. of silver per ton.

Bonshaw, P. & U., Bingara Dn.—Copper ore has been forwarded from this locality for assay, $\frac{1511}{98}$ yielded 58·29 per cent. of copper.

Bookham, near Yass, L., Boorowa Dn.—Copper and magnetic iron pyrites from Bookham yielded, $\frac{42}{90}$, from 12 to 51·34 per cent. copper.

Boone West Copper Mine. (*See* Anaconda.)

Booroolong, P. & U., Armidale Dn.—Red oxide and green carbonate of copper from this locality yielded, $\frac{46}{88}$, 67·77 per cent. copper. From fourteen miles N.E. of Booroolong Head Station, copper pyrites assayed, $\frac{1977}{98}$, 14·96 per cent. of copper and 9 oz. silver.

Borah Creek Mine, now the "*Conrad Silver-lead Mining Company*," P. & U., Tingha Dn., Parish Mayo, County Hardinge, about three miles from Boggy Camp Diamond Mines.—The Borah Creek Silver, Lead, and Copper Mine has recently been purchased by Mr. John Howell, of Howell's Consolidated Mines, and vigorous development is in progress. The lode occurs in granite, and its softer nature has determined the course of a small creek. Silver and lead are the chief metals present, though copper sulphide occasionally is also solid. The lode stuff is very friable and easily broken. Arsenical pyrites is an associate. 13 tons 4 cwt. 3 qrs. 5 lb. treated at the Smelting Company of Australia's Works, Dapto, yielded 12 cwt. of copper —equivalent to about 4 per cent.

Boro, S., Braidwood Dn.—In 1873 the English and Australian Copper Smelting Works at Waratah treated 1 ton 11 cwt. of ore from this locality (probably from Mulloon Copper Mine) for a yield of 12$\frac{3}{4}$ per cent.

Boro Copper Mine, S., Braidwood Dn., about half a mile south of the Mulloon Copper Mine.—Discovered by George Scott, about 1878, at which time it was sunk 80 feet and driven 50 feet south. The country consists of slates and sandstone, with limestone in close proximity. The lode strikes N. and S., and dips west, and has a thickness of 2 to 6 feet, but is much broken and mixed with country.

The present owners—Thomas and Party—entered into possession about October, 1898, and stoped up from the 50-foot level for a length of 50 feet, bunches of good carbonates being obtained.

The following returns were obtained from the Smelting Company of Australia, Dapto:—

7 tons copper carbonates	Copper, 18·7 per cent. Gold, 6 dwt. 6 grs. per ton.
4 " "	Copper, 22·6 per cent. Gold, 1 oz. 1 dwt. 19 grs. per ton. Silver, 2 oz. 16 dwt. 19 grs. per ton. Silica, 31·1 per cent.
2 tons	Copper, 12·5 per cent. Silica, 38·3 per cent. Gold, 1 oz. 12 dwt. 9 grs. per ton. Silver, 2 oz. 9 grs. per ton.
9 tons	Copper, 15·9 per cent. Gold, 8 dwt. 11 grs. per ton. Silver, 2 oz. 2 dwt. 11 grs. per ton.
6 tons	Copper, 19·7 per cent.

The 80-foot level was being prepared for driving along the course of the lode. Sulphides of copper and iron with a little zinc sulphide appear at this level. A cwt. sample sent to Dapto yielded 9 per cent. of copper and 7 dwt. of gold per ton.

Bouchier's Mine. (*See* Tuglow.)

Braidwood District, S., Braidwood Dn.—Copper ores have been reported and tested from the following localities in this Division:—

Thames Gully, $\frac{2162}{96}$; yield, 6·5 per cent. copper.

Enderick River, $\frac{2265}{96}$; yield, 13·6 per cent. copper.

Green Creek; in 1885 a sample yielded 42·45 per cent. of copper and 29 oz. of silver per ton.

Mulloon Creek; ore yielding 22·45 per cent. copper.

Currowan Creek, about twelve miles E. of Braidwood, Mr. E. C. Whittell, Field Assistant, states that McGuinness' lode occurs in a belt of andesite traversing Carboniferous rocks at the head of the above creek. Large bunches of epidote and small irregular veins and bunches of quartz occur in the andesite. The quartz veins vary from a few inches to a foot in thickness, but are not continuous for more than a few feet in length or depth. Native copper and yellow and grey sulphides are present in the quartz. In 1898 two mineral prospecting areas were applied for for copper-mining at Sugar-loaf, on the Braidwood Mountains, but little work was done.

Bredbo, T. & A., Cooma Dn.—Copper ores are reported from one mile from Bredbo Railway Station; also from three miles—a sample from the latter ($\frac{2560}{97}$) yielded 37·17 per cent. copper.

Brewongle, B., O'Connell Dn.—Copper pyrites and galena in talc schist from Brewongle yielded ($\frac{27}{89}$) 7·78 per cent. copper.

Broken Hill Proprietary Silver Mine.—In the famous Broken Hill lode copper ores are disseminated in the form of carbonates, red oxide, and native copper, with other rarer varieties, including a new mineral—Marshite—(iodide of copper) described by Professor Liversidge.* Since the start of the company in May, 1885, to the 30th November, 1898, 4,043 tons of copper have been produced, the first return being 25 tons in 1892. The secretary to the company states that to 26th May, 1898, 18,782 tons of copper matte were produced, containing 3,786 tons of copper and 1,882,091 oz. of silver. Before shipment the matte is further treated and brought up to a grade of contents equalling—

Copper...	35 to 40 per cent.
Silver	110 to 180 oz. per ton.
Lead...	10 to 15 per cent.

Broombee, near Mudgee, M., Mudgee Dn.—In $\frac{1886}{p.135}$, the late Government Geologist, Mr. C. S. Wilkinson, recorded the presence of copper at Broombee.

Broula Range, L., Cowra Dn., about eleven miles S.W. of Cowra.—Aid was granted Connelly and Party to prospect a copper lode near Broula, but the result was not encouraging. The outcrop consists largely of magnetic iron oxide in granite and dioritic (?) country.

Brown's Creek, near Blayney, B., Blayney Dn. (*See* Icely Copper Mine.)—Portion 7, Parish Errol, on Brown's Creek, about half a mile south of Brown's Creek Gold Mine, and in Portion 40, Parish Beaufort, copper ores occur. Copper is also present in minute quantities in the Brown's Creek Mine. A Lithgow syndicate has recently started prospecting operations at Brown's Creek.

* Procs. R. Soc. N. S. Wales, 1892, XXVI, p. 328.

Brungle Hill, T. & A., Tumut Dn.—Copper ores were first mentioned in this locality in 1880. The country is serpentine.

Bucca Creek, C. & R., Nana Creek Dn.—Copper ore, purporting to come from Bucca Creek, was assayed ($\frac{1722}{97}$) for a yield of 42·86 per cent. of copper, but particulars are not available.

Buckenbah. (*See* Goodrich.)

Buddawang Range, S., Ulladulla Dn., six miles from the village of Little River.—Rich copper specimens reported in $\frac{1888}{p. 71}$, but the lode was not discovered.

Budjong, S., Goulburn Dn., twenty-two miles from Goulburn.—A sample from Budjong ($\frac{1441}{98}$) yielded 57·62 per cent. copper.

Bulga, B., Orange Dn.—The Australian Museum contains native copper and black oxide from this locality, but no particulars are available.

Bull's Creek, B., Oberon Dn., Parish Jenolan, County Westmoreland.—Copper ore occurs (bornite) about one mile north of Portion 5, on Bull's Creek, also about one and a half mile south of the same portion on the same creek, near its junction with the Jenolan River. Shafts have been sunk on both outcrops. The ore occurs in chlorite in very rich, small bunches, assaying up to 37 per cent. copper. (*See* Hampton Mine.)

Bumbery Copper Mine, also known as Payne's Mine, L., Cudal Dn., 9 miles south-easterly from Bumbery Railway Station, Molong to Parkes line.—This lode was originally opened as a gold mine in 1896; the outcrop consists of gossan, from 40 to 50 feet wide. At 30 feet carbonates and grey sulphide of copper were struck. At present time the shaft is over 100 feet deep, but the width of the lode at this level has not been ascertained, as the shaft is in one of the walls. The following parcels of ore have been treated during progress of the work:—10 tons sent to Lloyd's Smelting Works, Lithgow, yielded 26⅓ per cent.; 3 tons sent to the Smelting Company of Australia's Works, Dapto, yielded 36⅛ per cent. In February, 1899, the Writer inspected this mine, which was being worked by the original proprietors—Payne and Party—the holders of a purchasing option having forfeited their deposit. The deepest shaft was then 130 feet, but the oxidised zone had not been penetrated. Rich bunches of secondary ore—copper glance—were struck by the present party on resuming operations, from which the following returns were obtained at the Smelting Works, Dapto:—

4 tons	14 cwt.	"Firsts"	yielded	42·6	per cent	of copper.
4 „	16 „	"Seconds"	„	27·8	„	„
2 „	10 „	"Thirds"	„	21·8	„	„

In the north shaft (130 feet) a large body of gossan has been exposed, in which crystalline native copper occurs in places from redeposition from solution. The rich copper glance occurs in bunches in the gossan at 130 feet. There is every probability of larger masses of this ore being found about the true water-level. Crosscuts have been driven east and west from 40 to 50 feet, revealing a very large and promising body of oxidised material; but the extension of the eastern drive at the 100-foot level for a considerable distance into the solid country is labour in vain. Efforts should be concentrated on piercing the oxidised zone, and proving the unaltered lodestuff below. Until this is done, the real value of the lode cannot be estimated.

The south shaft has been sunk 112 feet, and crosscut 40 feet east. Here the outcrop consists of red jasperoid altered rocks, heavily charged with pyrites. Epidote rock is also in proximity. Quartz porphyry forms the country.

Bundarra Copper Mine, P.U., Barraba Dn., Emu Creek, at S.E. corner of Portion 77, three miles south of Bundarra, and one mile west of the Gwydir River.—Mr. Jaquet, Geological Surveyor, reported ($\frac{1897}{p.\ 183}$) that "the geological formations consist of altered slates, claystones, &c., which are to a very large extent impregnated with ironstone near the surface, while occasional bands of compact ironstone, associated with manganese, occur, which dip downward, and may proceed to great depths.

"It is from one of these bands of ironstone that patches of rich copper ore have recently been obtained by Messrs. Russell and Party. This party having discovered traces of carbonate of copper in the outcrop of a massive ironstone lode, have, by means of a shaft and short crosscuts, proved the same to a depth of 150 feet. Some rich ore has been obtained, but it occurs in patches, and no defined shoots have been discovered. At a depth of 95 feet the lode is about 5 feet wide. A level has been driven along it for a length of 30 feet, and a small bunch of rich sulphide ore has been encountered. Parcels of this ore have been treated at the Newcastle Smelting Works, and yielded as follows:—

6 tons	33 per cent. copper.
18 tons	6¼ „ „

Copper pyrites can be seen in a crosscut at 130 feet. Upon the footwall side of this lode a shaft has been sunk 84 feet in the country rock, which is here impregnated with copper carbonate with some black ore."

Up to August, 1898, 72 tons of ore from the mine had been received at the English and Australian Smelting Works, Waratah, which yielded about 17 per cent. of copper.

Bundundah, S., Yalwal Dn.—In $\frac{1882}{p.\ 76}$, the Warden reported that Captain Reynolds had started a copper mine in a gully of Bundundah Creek. Shaft sunk 90 feet; driven north 40 feet, and south 30 feet, at 50-foot level. Eight to 10 tons of ore raised estimated to yield 25 per cent. copper. Strike of lode, north and south.

In the same year Mr. E. F. Pittman, then Geological Surveyor, ($\frac{1882}{p.\ 160}$) reported on copper at Bundundah Creek—probably the above—and stated that a lode from 18 inches to 2 feet thick, consisting of hematite, galena, and a little metallic copper occurred here in granite. An assay gave a return of 20·8 per cent. lead, 3 per cent. copper, and 60 oz. of silver per ton.

Bungonia District, S., Goulburn Dn.—The Jacqua Copper Company, on Jacqua Creek, about 12 miles from Bungonia (Parish Inverary, County Argyle), drove 60 feet into side of range, and then abandoned the site. From Jacqua Reef ore assaying ($\frac{2890}{95}$) 8·18 per cent. copper, and ($\frac{2187}{97}$) 12·4 per cent. copper was received.

Doctor's Copper Lode, Jacqua Creek (probably identical with Jacqua Copper Mine) was recently inspected by Mr. E. C. Whittell, who regarded it as very unpromising; the copper ores occurring only in small veins, some mere threads, in a formation from 3 feet to 4 feet thick.

Copper ores also occur at Cryer's Arm and Spring Creeks; in the latter near its junction with the Shoalhaven River. The ore here consisted of copper pyrites, galena, blende, and mispickel. The deposit was opened under aid from the Prospecting Vote, but did not prove extensive enough to work. Its assay value determined in 1892 ranged from 13 to 22 per cent. of copper.

Bunnamagoo. (*See* Summerhill Copper Mine.)

Burley Jacky Copper Mine, B., Cowra Dn., situated on the Redfern Estate (now Cobb & Co.'s), about four miles from Woodstock Railway Station, on the Blayney to Harden Railway.—The following particulars were supplied by Mr. Hemsley, of Blayney:—Burley Jacky lode was discovered in 1877. Two waggon loads (about 12 tons) were sent to the Cadia Smelting Works, near the Canoblas; this apparently exhausted the ore in sight, for nothing more seems to have been done in the way of raising ore until 1890, when a very rich bunch of copper sulphide (bornite) was discovered upwards of 30 feet in width, and of an equal length. This chute was followed to the 230-foot level, when it cut out. The ore averaged 30 per cent. at the English and Australian Smelting Works, Waratah, and is stated to have realised a net return of about £47,000.

The lode occurs in andesite at the junction of sedimentary rocks. The lode channel is filled with boulders of andesite of all sizes up to several tons. Between the boulders, soft, crushed, or clayey filling occurs, stained with copper carbonates, and containing bornite in bunches. The main bunch was cut off northerly by a cross joint in the andesite. Since the exhaustion of the rich ore chute attention has been directed to the outcrop further north. Very kindly gossan occurs both at the main workings and at the northern extension, several chains distant. Several shafts have been sunk hereabouts in promising gossany carbonates with red jasper and chalcedony. The mine requires a deep test with adequate levels along its course. The richer (secondary) ores are likely to occur in isolated bunches, such as already discovered, but at greater depths the original yellow sulphide may prove to be more equally distributed in the lode. The rich and profitable chute already described was found only a few feet below the original workings after the mine had long remained idle. Two other lodes have been discovered on the property during 1898; the furthest west, half a mile from the main lode, has recently been opened to 70 feet. The lodestuff, 2 ft. 6 in. thick, consists of quartz with copper sulphide, but is not rich enough to bear cost of carriage and treatment. Gold is reported to have equalled 2 oz. to the ton of metallic copper; a sample of bornite, taken at random, yielded but a trace (under 2 dwt.) of gold per ton, and 9 oz. 14 dwt. 4 grs. of silver per ton. It does not appear that the owners derived any benefit from the presence of the precious metals. About three-quarters of a mile northerly from Burley Jacky Mine, on the adjoining land, a little copper carbonate is showing in the andesite, and in a quartz reef some evidence of early superficial testing is apparent.

Burra Burra Station, L., Trundle Dn., ten miles north of Fifield.—Samples of copper ores from this station have been tested ($\frac{1972}{96}$) for yields varying from 4 to 7 per cent. copper, and a little prospecting has been done.

Burrabungie Mine, Cobar, Cobar Dn.—This mine lies between the Cobar Chesney and Mt. Pleasant Mines. The shaft is being sunk on the south boundary of the former, close to an outcrop of ferric oxide. At 200 feet a crosscut west under this outcrop passes through about 10 feet of iron pyrites, part of which is solid and part mixed with the slate country. Very little copper sulphide occurs with the pyrites. Above the sulphide level the rotten slate carries stains of copper carbonate.

Burraga Copper Mine, B., Burraga Dn. (formerly *Thompson's Creek Mine*).—According to Mr. T. Russell, of Blayney, brother of one of the original proprietors, the Burraga Mine was discovered by a shepherd named McIntyre prior to 1877, taken up by Mr. Brownlow, of Briar Park, and transferred by him to Messrs. James Russell and Clarke. The lode is reported to have been very thin at surface, with very little gossan. At 18 feet it opened out to a width of 18 feet of black ore, equal to 19 per cent. copper.

The following report was furnished to the Warden in ($\frac{1878}{\text{p. }61}$), by Messrs. Russell & Co.:—"We commenced work on the 3rd January last with two men, and now employ thirty-three, including teamsters. Clarke's shaft is sunk to a depth of 62 feet. The lode in this shaft is about 8 feet wide from the bottom to near the surface of 20 per cent. ores. The lode is disordered at the bottom of this shaft, this being the place of junction with an east and west and north and south lodes. The lode going south from this shaft is about 4 feet wide of black and yellow ore, and is continuous to No. 1 shaft north.

"No. 1 shaft is 40 feet deep, the lode being from 2 to 3 feet wide of yellow ore. Other prospecting has been done further north with good prospects."

From Clarke's shaft a drive was put in on the east and west lode, which was reported about 8 feet wide of yellow ore. Shaft No. 1 east was sunk 57 feet in a strong lode of sulphides. At the eastern end red oxide was reported. The last parcel of ore sold from this lode gave $43\frac{1}{5}$ per cent. copper. No. 2 shaft, 60 feet, in yellow ore at bottom. No. 3 shaft, 60 feet, lode 5 feet wide; value, 22 to 26 per cent. (Extracts from Russell & Co.'s report.)

The ore was at this time being carted by teams to the Cow Flat smelters at a cost of 35s. per ton.

In 1879 work was continued, but the want of local smelting furnaces was militating against the development of the mine. Subsequently it passed into the hands of the present owner, Mr. Lewis Lloyd, who had erected smelting and refining works at Lithgow, on the Western Railway line.

In 1880 the erection of reverberatories at the mine was commenced, the ore meanwhile going to the Lithgow Works, 427 tons being raised and dispatched during the year.

In 1881 the mine was in full work. The original name of Thompson's Creek Mine was in this year altered to Burraga. Four reverberatory furnaces were in full work and three others were in course of erection. One hundred and ten men were employed, 2,500 tons of ore being raised, producing 250 tons of refined copper, valued at £16,000.

The method then adopted is still in force, viz., reducing the ore to regulus of about 40 per cent. grade and refining at Lithgow, where coal and fireclay and easy freightage to market are available. The regulus is carted to Perth Railway Station, a distance of about thirty-five miles.

In $\frac{1882}{\text{p. }35}$, the Mining Registrar reported that two hundred men were employed. Five furnaces were in full work. The output reached 4,450 tons, yielding 465 tons of copper, valued at £32,550.

The depth of main shaft, 180 feet; deepest level, 170 feet; width of lode, 7 feet. Population, about 400.

In 1883, 6,150 tons of ore were raised, producing 520 tons of copper, valued at £36,400.

In 1884 the only particulars given were that 582 tons of copper had been produced, which at previous valuation (£70 per ton) would equal £40,740, but this figure is obviously in excess, as the average market value (London) for this year was but £54 15s. 6d. according to H. Merton & Co.

In 1885 work was continued, the lode being reported as rich as ever at the 228-foot level, with a thickness of 6 feet. One hundred and fifty men were employed and 4,215 tons of ore raised, producing 440 tons of copper, valued at £22,500, or about £50 per ton.

In 1886 work was suspended owing to the low price of copper (averaging £40 6s. according to the above authority). For the nine months ending 30th September 281 tons of copper were produced, valued at £14,000.

After being closed for twelve months, the mine was reopened in September, 1887; during the rest of the year 120 tons of copper were produced, valued at £7,500.

During 1888 operations continued in full swing, 499 tons of copper being produced, valued at £36,000. (Copper in this year experiencing a great rise owing to the operations of a French syndicate, the average value reaching £76 per ton.) The lode at 300 feet was reported to be 15 feet wide; 170 men were employed.

In 1889 the mine was shut down for six or seven months; afterwards 300 men were employed, but no returns are available.

Full work continued in 1890, 420 tons of copper being produced, valued at £24,150.

At the end of 1891 all but six hands were discharged owing to the low price of copper, the average market value having fallen to £51 3s. during the year. Returns of copper were not given for this year. Furnaces reducing ores at grass.

In 1892, 800 tons of ore were raised, but not all smelted. Eighty tons of copper were produced, valued at £3,600.

In 1893 the mine was idle until November, when one hundred and fifty men were employed. The deepest level at this date being 750 feet; lode, 9 feet wide and improving.

During 1894 full work continued, 622 tons of copper being produced, valued at £24,800 = £40 per ton.

In 1895 work continued, with the exception of a brief interval in June, when the lode was lost; when recovered it was less rich than hitherto. This fact, combined with a labour dispute, reduced the output of ore to 3,311 tons, producing 331 tons of copper, valued at £14,895.

The output during 1896 amounted to 424 tons of copper, valued at £19,928 (£47 per ton), evidencing a rising market. One hundred and fifty men employed.

In 1897 the mine was worked full time, 150 hands being employed; 8,907 tons of ore were raised; estimated value of copper sold, £34,896.

During 1898, 8,518 tons of ore were raised, 5,678 tons were smelted for 570 tons of copper, valued at £28,500. The balance, 2,840 tons of seconds, being estimated to contain 142 tons of copper. One hundred and fifty men employed.

BURRAGA COPPER MINE.

Burraga Copper Mine.
(Part of working face, 800-ft. level.)

Summary of Output from Burraga Mine.

	Tons of Ore.	Tons of Copper produced.	Value.	Remarks.
			£	
1880	120	....	....	43½ per cent. of copper.
1881	2,500	250	16,000	
1882	4,450	465	32,550	
1883	6,150	520	36,400	
1884	....	582	40,740	Estimated value.
1885	4,215	440	22,500	
1886	....	281	14,000	
1887	....	120	7,500	Three months' work.
1888	....	499	36,000	
1889	....	....	....	No returns. Mine closed for several months.
1890	....	420	24,150	
1891	....	....	....	No returns.
1892	800	80	3,600	Part only smelted.
1893	....	....	....	Restarted.
1894	....	622	24,880	
1895	3,311	331	14,895	
1896	....	424	19,928	
1897	8,907	....	34,896	
1898	8,518 (5,678 firsts smelted).	570	28,500	2,840 tons of seconds, estimated to contain 142 tons of copper; 150 men employed.

The Burraga Mine occurs in a belt of highly-altered rocks shading from porphyry into schist and slate? Samples selected by the writer have been microscopically examined by Mr. Card, A.R.S.M., Curator and Mineralogist, and the following determinations arrived at:—" No. 3,308, a fine-grained rock with gneissose structure. It consists of quartz, plagioclase, calcite, and biotite with iron ores. It has a fragmentary appearance, but is in all probability an acidic igneous rock altered by pressure. No. 3,307 is much finer grained and highly altered. It appears to represent a more highly-altered form of 3,308."

The strike of the beds near the engine-shaft is N. 20° E., dip S. 70° E. at 36°.

The direction of the present face (800-foot level) is about N. 70° E., with a very flat dip S. 20° E. The underlay, in fact, is so flat that descent and ascent is practicable without ladders; in some instances it departs but 15° from the horizontal, at intervals it steepens for short distances. The miners are, therefore, enabled to work upright at the face, as in a quarry, whilst practically underhand stoping.

Judging by the immense open cavities from which the ore has been extracted, the lode in places must have been of considerable thickness; at the present face it is equal to the height of the men, and the length of the shoot about 100 feet, so far as opened. Naturally pinches occur in places, generally where the channel approaches most nearly the horizontal, giving rise sometimes to fears that the lode was giving out, but there is little danger of such a catastrophe within a considerable depth, though fluctuations in thickness and ore tenor must be expected.

Owing to the absence of water in the lower levels, and the hardness of the country, timbering is almost entirely dispensed with, an occasional pillar and prop being sufficient for the security of the workings. These facts, combined with the absence of extraneous fluxes in smelting, are important factors in the economic working of the mine.

The ore is mined by day-labour, and is dressed at surface to 10 or 12 per cent. grade for the smelters. The raggings are screened, and the fines jigged by means of a small hand-jig, supplied with a little surface seepage water from the mine, and subsequently used for blinding the roast-heaps, which are well situated on a ridge slope about midway between the mine and the furnaces. The dressed ore is conveyed to the roast-heaps, and the calcined ore from the latter to the furnaces by horse-tramway.

The smelting plant was originally placed close to the mine, but was discarded because of insufficient room for wood-stacking, owing to the configuration of the country.

Three reverberatories are now in use, with wood firing, at a cost of 4s. 6d. per ton. The regulus is brought up to about 40 per cent. in one operation, in which state it is dispatched to the refining plant at Lithgow.

The ore is apparently free from injurious mineral associates. Calcite occurs in portions of the lodestuff to the advantage of the smelter. Pyrites is not present to any appreciable extent.

Heap roasting is carefully carried out on a foundation of rough screenings.

Fireclay is obtained about 2 miles from the mine, which answers excellently all purposes required of it in the smelting furnaces; an analysis, showing its composition, will be found in the section devoted to refractory materials.

One of the most important features connected with the Burraga Mine is the large proportion of "seconds" which, since the earliest workings, have been discarded, none but direct smelting ores being treated. In the immense heaps or "burrows" a large amount of ore is locked up awaiting concentration. Doubtless under private ownership there has not been the same necessity or incentive to turn everything to account as would be required of a public company. Owing to tarnish, the recent seconds appear of higher grade than those long exposed. The matrix is chiefly siliceous, hence the difference in specific gravity between it and the copper ore—chalcopyrite—is sufficient for mechanical separation, the relative figures being 2·6 and 4·1 to 4·3. Lean siliceous sulphides are concentrated over buddles and vanners in Montana, and there is no reason why similar means should not be as successful here.

Every facility is available in the vicinity of the mine for abundant water conservation for concentrating purposes.

A sample of the Burraga sulphides was submitted to assay for gold and silver, with the following results:—$\frac{2220}{99}$; silver, 2 oz. 19 dwt. 21 gr. per ton; no gold. The sale of this mine for £100,000 cash to an English Company is being negotiated, a substantial deposit being posted.

Burraga District.—About one mile south of the Burraga Mine the Mining Exploration and Development Company are prospecting private land. A lode channel from 3 to 4 feet wide is being opened, having a N. and S. strike, and dipping E. at 50°. The lodestuff consists of quartz, with copper and iron sulphides and a little zinc blende in crushed country. A sample, $\frac{4302}{98}$, yielded—copper, 8 per cent.; zinc, 16 per cent.; and silver, 2½ oz. per ton.

A short distance west, in the bed of a small creek, a very kindly-looking gossan is exposed for a considerable width. Traces of copper carbonate are visible in freshly-broken fragments. An assay, $\frac{4303}{98}$, yielded but a trace of copper—0·1 per cent.—and under 2 dwt. of gold per ton. It is, however, worthy of adequate testing, as it has all the appearance of a thoroughly leached cap of a pyritous lode.

Burraga Copper Smelting Works.

McKenny, Hall, and Party are prospecting a 12-inch copper vein in hard country about 1¼ mile south of Burraga; depth of proving, 50 to 60 feet.

Stain, Cassell, and Party are testing another vein, under aid from the Prospecting Vote, about two miles S.E. of Burraga. The channel has a width of about 3 feet. A little carbonate occurs near surface, but at 90 feet there is little trace of copper, the sulphides being almost entirely iron pyrites. At 140 feet a 2-foot lode of better class siliceous ore has recently been struck in this property.

On Hockey's property, which adjoins the Burraga Mine area on the east, a shaft is being sunk near the boundary within a few hundred feet of the Burraga workings to cut the main lode on the underlay. The surface level of the shaft is about 275 feet above the mouth of the Burraga inclined shaft, which starts in the outcrop. The exact amount of dip in the latter has not been ascertained. It is probable, however, that the vertical shaft will cut the lode at the boundary under 600 feet or thereabouts. There is little doubt that the lode passes into Hockey's property.

Burrawang Copper Mine, near Cumnock.—Now being re-opened.

Burrogorang Mountain, S., Picton Dn. (*See* Peaks.)

Burrowa District, S., Frogmoor Dn. (*See* Frogmoor Copper and Mayfield Mines).—Copper ores occur at Arkstone Forest, seven miles east of Burrowa, where shafts were sunk thirty years ago. Lang's Creek copper lode was opened to a depth of 75 feet over twenty years ago. Kenyu Copper Mine, parish Kenyu, county Monteagle, opened to a depth of 80 feet by Mr. S. L. Bensusan. From a locality eighteen miles N.W. of Burrowa a sample yielded $\frac{1367}{97}$ 15·89 per cent. of copper. Copper pyrites from four miles S. of Rye Park yielded $\frac{2331}{98}$ 26·56 per cent. of copper.

Burt's Copper Mine, Spring Creek, Larras Lake, L., Molong Dn.—This lode was opened by Messrs. Roberts and Evans about 1872. About 20 tons of surface ore was sent to Cadia Smelting Works, but the result is not known.

Bushy Hill, Cooma, T. & A., Cooma Dn.—Copper carbonates are present in small quantities in the auriferous felsite of Bushy Hill. At Blake and Party's Mine copper ores are present in appreciable quantity, but their value is overshadowed by the gold contents, which averaged over 5 oz. per ton for 26 tons treated at the Australian Smelting Works, Dapto, to date, 15th May, 1898.

Byng, B., Orange Dn.—In addition to the Carangera, Ophir, and other copper mines near Byng, which receive independent notice, copper ores occur on Mr. W. Hawke's property about twelve miles S.E. of Orange. The lode was discovered several years ago during fencing operations. It strikes N.E. and S.W., and dips S. easterly. The outcrop is from 1 foot to 1 ft. 6 in. in thickness; at 8 feet it increased to 2 feet, below this it appears to pinch. The ores consist of carbonate and black oxide, which have not yet been tested.

On Mr. Webb's property, near Byng, a copper lode occurs, from which the following parcels of ore were treated at the English and Australian Smelting Co.'s Works, Waratah:—

6 tons	16 cwt.	yield	19½	per cent.	copper.
7 ,,	1	,,	16¾	,,	,,
3 ,,	2	,,	12	,,	,,

Bywong, T. & A., Bungendore Dn., Parish Bywong, County Murray.—The Mining Registrar reported in 1891 that rich samples of copper ore had been obtained from Walsh's copper lode about nine miles N.W. of Bywong.

The Warden reported a poor lode about one mile west of Bywong.

Cadia Copper Mine, B., Orange Dn.—The earliest official record of this mine is that contained in the Official Catalogue of the Sydney Exhibition of 1870; on page 443, the Cadiangulong Copper Company was reported to have extensive works above and below ground, including a complete range of furnaces. The mine is situated on Cadiangulong Creek, fifteen miles south of Orange, and is owned by the Scottish Australian Investment Company, from whom particulars of past operations are not obtainable. In 1881 the late Government Geologist—Mr. C. S. Wilkinson—reported the Cadia lode to be 6 feet in thickness, and the ore chiefly yellow sulphide associated with quartz. It dips N.N.W. at 75°. He also mentioned that about half a mile N.E. from this lode a large cupreous ironstone or gossan lode crosses the main creek. [The Iron Duke.] It has a thickness of over 70 feet, and strikes N. 20° W. So far as tested the lode was not rich enough to work for copper, but Mr. Wilkinson was of opinion that when sunk upon to water-level, where the sulphides would be found undecomposed, good ore would be met with.

In 1882, 48¼ tons of ore were obtained at Cadia, and a little tributing was done in 1883.

Recently the Writer visited the locality; little information was obtainable, a law suit involving an appeal to the Privy Council was pending, owing to authority to enter having been obtained by two miners who subsequently applied for gold leases covering the Iron Duke lode under the provisions of the Mining on Private Lands Act.

Several lodes occur on the property, the principal ones being the Cadia and Iron Duke. The main shaft of the Cadia reached a depth of about 232 feet; 120 feet vertical, 60 on the underlay, and 40 feet in a winze. The lode was about 12 feet wide, with good ore at surface, and about 5 feet at bottom, but low grade and dreggy, with abundant iron pyrites. The main stope was about 50 feet long. Work has not been carried on for twenty or twenty-five years in this shaft. A substantial stone engine and pumping house was erected. The water, raised by a beam engine, was used for concentrating purposes; the remains of a set of jigs are still to be seen. The smelting furnaces were erected on Cadiangulong Creek, a short distance from the mine.

The Iron Duke lode has been opened by tunnel and shaft. The former, 1,300 feet long, according to the Manager of the Scottish Australian Mining Company which owns the property, starting from the west bank of the creek, passes through the ironstone lode in which a little copper ore is visible in places. For a considerable distance after passing the ironstone the tunnel pierces, in a most erratic, winding manner, solid andesitic country destitute of any trace of lode formation.

Two crosscuts have been driven from the tunnel in the ironstone lode, and a considerable amount of stoping has been done, following a vein of good carbonate ore. About 2,500 tons of ore, averaging about 16 per cent., are reported to have been extracted under the direction of the late Captain Holman.

Where the creek cuts across the lode a rich vein of carbonate and red oxide, 3 to 4 feet wide, was discovered ten or twelve years ago, about 40 tons being extracted. A shaft was started about twelve months ago, close to the bank of the creek, to continue opening this find, but was stopped owing to the litigation already alluded to.

On the opposite side of the creek from the tunnel, a large face of gossan has been exposed, through which traces of copper carbonates are visible. A shaft was sunk at this point to a depth of about 280 feet. A little ore from it can still be seen at surface, consisting of sulphides of iron and copper.

The latest smelting at this site was about ten or twelve years since, when some 4,000 to 5,000 tons are reported to have been treated.

The tunnel has recently been cleaned out, and is in excellent condition, but the greater part of its length appears entirely off the course of the lode, which runs across and forms the top of a small hill. The tunnel-level is too shallow for effective test of the lode; greater depth is necessary than that attained in winzes—about 40 feet—below the tunnel-level.

Certainly the shaft on the opposite bank of the creek has pierced the sulphide zone, but it is doubtful whether drives, if any, from that level have penetrated into the hill to the west. The frequent barrenness of ironstone caps of copper lodes, due to the unstability of copper salts in the presence of leaching solutions, encourages the belief that more concentrated bodies of the ores of that metal may be found below the oxydised capping in this instance. Certainly efforts should not be relinquished until the sulphuret zone has been explored under the main outcrop.

The abundant ironstone of the Iron Duke cap would be of excellent service in fluxing the sulphides from a depth, if such exist in payable quantities; failing this as a suitable flux for public smelting works, it will have a value in the future. The small percentage of copper carbonates disseminated through it will debar its use for iron smelting because of the deleterious effects of copper on iron, rendering it "red-short," or brittle at a red heat.

Whilst writing of Cadia, it is desirable to refer to a report by the first Government Geological Surveyor—S. Stutchbury—in July, 1851, in which he alludes to the existence of strong evidence of copper lodes in the neighbourhood, which do not appear to have been followed up. The following extract contains the reference :—" In a gully or creek called the Waterfall, running into the Cadiangulong or Oaky Creek, at the western end of a section of 640 acres, forming Lot 1, for sale May 7th at Carcoar, and at the extremity of a mountain spur known as the Rocky Range [Canoblas? these creeks rise in the Canoblas.—J.E.C.], there is an immense mass of oxydulous iron, forming in one solid mass a precipitous waterfall of about 60 feet in height. In this mass of iron, especially in the joints, there is brilliant crystallised iron pyrites, with a small quantity of yellow copper ore, and traces of blue and green carbonates of copper. A few yards below the waterfall large masses of yellow ochreous iron 'gossan' occur in the banks and bed of the creek. This gossan contains a considerable quantity of earthy green carbonate of copper, also plush-like malachite. Upon sinking a short distance into it on the eastern side, a rich lode of grey sulphuret of copper was found. In traversing the creek southwards, numerous indications of other lodes were visible, together with large masses of mundic."

If not already located and tried, the physical features above described should lead to its discovery.

Camelback Mountain, C. & R., Grafton Dn.—In a report, dated 1853, the Rev. W. B. Clarke reported abundant indications of copper and lead near the Camelback Mountain.

Canning and Gibson's Mine, S., Captain's Flat Dn.—This property, M.L. 86, situated one mile from Captain's Flat, was examined in 1890 by Mr. Harrie Wood, Under Secretary for Mines. At this time three shafts had been sunk 25, 50, and 60 feet respectively. (*a*) 25-foot shaft sunk through broken veins, no defined lode. (*b*) 60-foot shaft sunk on a well-defined lode, with black shaly ore, about 4 feet wide; the eastern side of the black lode-stuff contained native copper. (*c*) 50-foot shaft sunk in an irregular deposit of grey ore at surface. At 50 feet the lode was reached by crosscut, ore veins up to 1 foot thick occurring in it.

The following parcels of ore from the mine were treated by direction of the Prospecting Board:—

No. 1.—15 cwt. 2 qrs. 14 lb., consisting of carbonates of lead and copper in clayslate, with a little quartz, yielded—

Copper	6·65 per cent.
Lead	6·95 ,,
Gold	2 dwt. per ton.
Silver	5 oz. 7 dwt. 2 grs. per ton.

No. 2.—2 tons 19 cwt. 3 qrs. 18 lb. carbonate of lead, with a little carbonate of copper, in ferruginous clayslate, yielded—

Copper	1·42 per cent.
Lead	9·97 ,,
Silver	3 oz. 6 dwt. 23 grs. per ton.
Gold	Nil.

No. 3.—17 cwt. 3 qrs. 18 lb. carbonates of copper and lead, with a little chalcopyrite, in clayslate, yielded—

Copper	13·40 per cent.
Lead	4·85 ,,
Silver	4 oz. 3 dwt. 7 grs. per ton.
Gold	Nil.

No. 4.—1 ton 0 cwt. 1 qr. 8 lb. carbonates of copper and lead, with a little chalcopyrite, in clayslate, yielded—

Copper	12·45 per cent.
Lead	10·45 ,,
Silver	4 oz. 16 dwt. 10 grs. per ton.
Gold	Nil.

Canoblas, B., Orange Dn.—Copper ores and native copper are associated with rocks of similar composition to those of the Canoblas, in the Orange, Carcoar, and Wellington Districts, and their possible connection has been referred to by Geological Surveyors David and Stonier, $\frac{1890}{p.\ 239}$, in the following terms:—

"Near Orange we inspected the Canoblas, the great extinct volcanoes of New South Wales, and found, as we had previously suspected, that the copper-bearing rocks of Waugoola and Walli, alluded to in previous geological reports, are probably lavas which have flowed from the vicinity of the Canoblas, and perhaps had their source in the Canoblas themselves. These lavas, as well as those seen at the 'Old Man Canobla,' are not basalts, but andesites, a variety of volcanic rocks whose existence in extensive sheets like these has hitherto never been recorded in New South Wales. Copper occurs locally, in a metallic state and as green carbonate, in the steam holes of this rock near Walli, and in a vein in the same rock near Wood's Flat at Waugoola."

Canoblas Copper Mine, B., Orange Dn., two miles from Cadia.—This mine was opened prior to 1859; beyond a little sulphide ore extracted occasionally to assist in fluxing the ores of the Cadia Mine when in operation some years ago, nothing has been done with the Canoblas Mine since the early days, so far as can be ascertained. The following report by Mr. J. Holman in 1872

has been kindly furnished by Mr. S. L. Bensusan, for whom it was made:—
"An immense iron lode runs through this property, and at a few fathoms south of it the copper lode has been partially developed from the east side of a gully. On either side of the latter the surface rises fast, and, by an extension of adits driven on the course of the lode, great depths may be attained.

"The copper lode was developed to a small extent about ten years ago [1862.—J.E.C.], when several parcels of good-quality ores were forwarded to, and sold in, England. Since that period some 300 or 400 tons of copper ore have been smelted at Cadia Copper Works, chiefly of low-grade percentage, obtained solely from the adit level extended about 30 fathoms into the eastern hill. However, the lode has not been sufficiently developed to determine its full width, although it has been seen fully 30 feet across.

"The lode has a very large promising gossan outcrop, and immense quantities of cupriferous pyrites are exposed on either side of the adit.

"A shaft has been sunk into this lode about 16 fathoms, where inexhaustible quantities of pyrites are exposed, and the water issuing therefrom holds in solution strong copper salts, which readily attack iron and precipitate pure copper in profusion. This feature gives every promise that large and rich deposits of copper ores are near at hand."

Canowindra, L., Canowindra Dn., in Marshall Bros. property, two and a half miles N.E. from Canowindra, in Parish Collett, County Ashburnham.—Mr. Inspector Milne states that the lode in this property is about 3 feet in thickness, with N.N.W. strike in porphyry, and a nearly vertical dip. The lode being strong, well-defined, and carrying good prospects, aid was granted in June, 1897, to continue sinking to the 60-foot level.

Capertee, T. & T., Sofala Dn.—Copper ore, from four and a half miles west of Capertee, ($\frac{1192}{97}$) was assayed for a return of 10·35 per cent.

Captain's Flat., S., Captain's Flat Dn., (See Lake George Mines, Canning and Gibson's Mine, and Grogan and Singleton's Mine).—The first official record of the discovery of copper ores at Captain's Flat is that of the Under Secretary for Mines in $\frac{1882}{p.\ 24}$, who mentions the finding of a copper lode on the Molonglo River which was thought likely to prove rich and permanent.

Mr. J. E. Wright, late of Currowoodgen, near Bombala, states that he discovered copper ores in the vicinity many years prior (1874) to the above announcement.

Carangara Copper Mine, Byng (formerly known as the Cornish Settlement), B., Orange Dn.—On 12th April, 1851, Mr. S. Stutchbury reported, after an inspection of this property: "The rocks, or 'country,' as the miners term the strata in which the lodes occur, are principally composed of clayslate, chlorite and talcose schists, with veins of quartz. No elvan has yet been seen; the lodes, large and small, are very numerous. No 'Champion' lode has yet been met with. The 'Master' lodes appear throughout the district to have a direction N. 20° W., with small, bifurcating, diverging, and large branches. The underlay is westerly, at an angle varying from 40° to 62°. At the level of the creek, and 27 feet to the north, they have commenced driving an adit which they find will clear them 18 fathoms from water."

Three shafts had been sunk at that time above the tunnel-level, but no particulars are given. The ores above the 10-fathom level are stated to have been similar to those of the Coombing Park Mine, near Carcoar; below that level sulphides occurred.

In August, 1854, a Select Committee of the Executive Council reported on the Carangara Copper Mining Company's Incorporating Bill, the Company having been projected about sixteen months prior to that date—April, 1853. The object of the Company, as stated in the Bill, was to work copper lodes in certain lands, and to purchase metallic ores, &c. The extent of the Carangara Estate being three portions of land 320, 156, and 320 acres respectively, in the Parishes of Byng and Anson, County Bathurst, formerly the property of Messrs. Lane and Glasson.

Copper ores from the mine were exhibited by the company at the Paris Exhibition of 1855. Mining and smelting was carried on in this locality for a number of years, but no particulars have so far been obtainable of the extent of the output.

In the vicinity, and extending to Lewis Ponds, the following mines were opened and worked about this time, and later, viz.—Britannia, Belmore, Moonta, Nelson, Gurophian, Ophir, Icely, East Block, Mt. Fraser, Algar, and others. Under the title of the Great Western Copper Mining Company, Ltd. (which see) most of these mines were floated into a public company in 1872. The first half-yearly report being issued in February, 1873.

In the Mineral Statistics of New South Wales prepared for the Philadelphia Exhibition in 1875, the following particulars are given of the lode worked at that time by the Carangara Company:—

Thickness of lode at	30 feet=	3 inches	Strike, N. 15° W. Dip, 60° westerly.
" "	180 " =	12 "	
" "	240 " =	18 "	

5,600 tons of ore raised yielded 784 tons of copper. Method of treatment being heap roasting and reverberatory smelting.

In 1881, the late Government Geologist, Mr. C. S. Wilkinson, visited Carangara; the mine was then idle. Mr. Wilkinson described the main shaft as being in a lode striking N. 15° W. through altered serpentinous schists and conglomerates, and dipping W. 20° S. at 53°. Near its southern end a wide quartz reef striking E. 10° N. meets the lode almost at right angles. Five chains higher up the creek is a white quartz porphyry elvan 20 feet wide, apparently running with the strike of the beds. Two other large quartz reefs occurred about half a mile further north. Mr. Wilkinson expressed the belief that the reefs and copper lodes would be found auriferous, which was subsequently proved. In 1886 both gold and silver were found to be present in the copper ores, and operations of late years have been confined to winning these metals. Tributing for gold has been carried on in the old mine for five years past, but the tribute has recently ceased owing to the intention of present owners to work the mine. Recently the writer visited a new shaft being sunk to cut a gold-bearing lode discovered in the old workings.

In 1898 an attempt was made by the present proprietors to smelt some 50 tons of copper ore, raised as a trial from the Mount Fraser and Algar Mines in the vicinity, with a view to their reopening. Apparently the result was not satisfactory, as operations were not continued. The ore was very siliceous, too much so in fact for smelting direct, hence the failure.

Carcoar District, B., Carcoar Dn.—In April, 1851, Mr. S. Stutchbury, Geological Surveyor, after describing the Coombing copper lodes, goes on to state that "the ranges south of the Carcoar Creek, east of the Coombing Estate, and west of Mount Lachlan 'Cambulla,' consist of alternating schists and syenite or granitic rock.

"On the two spurs from the little Mount 'Cambulla-narang' [Little Mount Macquarie ?—J. E. C.], I have opened several lodes of copper. The first appears to take a course W. 12° N. and E. 12° S. This lode close under the grass carries a thickness of 2 feet, with its underlay to the southward, and much valuable ore, principally tile ore and green carbonate of copper.

"In the creek about 150 yards north the back of another lode appears nearly 6 feet wide; this may be traced direct north over the next range until it reaches the main creek. On the summits of its course it is overlaid by rich crystalline magnetic iron ore.

"There also appear in the escarpment at the north end evidence of two parallel lodes, one on the eastern and one on the western side of the lode before described; these three lodes would not extend beyond 200 yards in lateral distance."

From camp near Curragurae, he wrote further of this district on the 18th July, 1851: "A few yards above the spring [on Lundy Swamp where Courageo Rivulet takes its rise.—J.E.C.] there are several lodes of 'gossan' carrying iron pyrites. At the mouth of the second gully below, several veins of chloritic, talcose, and quartzose stuff with great abundance of mundic; these I have but little doubt are the backs of lodes of yellow copper. On the west side of the main creek, immediately opposite the second gully below the upper fall, by moving a large body of rock containing pyrites, I discovered a fine vein of yellow sulphuret of copper, accompanied by green carbonate of copper; its width is about 1 ft. 6 in.; from appearance it was likely to be joined by two other thin branches or veins of yellow copper.

"At the first waterfall on the Maramur or Flyer's Creek, direct south from the spring heads, in Long Swamp, there is a lode of yellow sulphuret of copper crossing the creek direct east and west from section 1, Church and School Lands, into section of land consisting of 413 acres 3 roods 1 perch, for sale at Carcoar, 7th May [1851.—J.E.C.] There is a small lode-crossing in the same direction a few chains further south."

Further remarks on important indications in Waterfall Creek running into Cadia or Cadiangulong Creek are recorded under the Cadia Copper Mine in this register.

Between Carcoar and the Coombing Park Estate, at the north boundary of the latter, Messrs. Links have recently discovered traces of copper carbonates dipping rather flatly westward in schistose—or crushed—hornblende porphyry. Two shallow shafts have been sunk, and a third was being put down to cut the lode at a depth. A sample of copper pyrites from this site yielded $\frac{2892}{98}$ copper, 26¾ per cent.

In $\frac{1886}{p.66}$, a copper lode was discovered whilst making a road from Carcoar to the Cobalt Mine on McKillop's property. The Mining Registrar reported that a shaft was down 25 feet, and ore was being raised for dispatch to Newcastle, but evidently the quantity was very limited. A sample yielded $\frac{2380}{98}$ copper, 11 per cent. From Stoke's Estate, half a mile east of Carcoar, a sample of copper pyrites, $\frac{2897}{98}$, and $\frac{3199}{98}$, yielded 26 per cent. of copper, and 2 to 3 cz. of silver per ton.

Cathleen and Party were reported in the *Australian Mining Standard* of the 31st December, 1896, to have dispatched a truck-load of ore from a mine near Carcoar, but particulars were not given.

Cargo, L., Cargo Dn.—In $\frac{1890}{p.268}$, Mr. W. Anderson, Geological Surveyor, pointed out that in the lower levels of the Iron Clad Mine, Cargo, solid iron and copper pyrites occurred, and that generally the ore was more freely gold-bearing where the copper was most plentiful.

In 1888 a copper lease was taken up by Gazzard and Party, between the Iron Clad and Dolcoath Mines. Recently 10 tons of ore from the Iron Clad Mine were sampled and assayed at the Government Metallurgical Works, Clyde, with the following result:—

Copper	2·97 per cent.
Gold	19 dwt. 2 grs. per ton.
Silver	1 oz. 5 dwt. 5 grs. per ton.

Casino, Richmond River, C. & R., Casino Dn.—A zinciferous sample from four miles from Casino yielded 4·59 per cent. copper, and 25·84 per cent. zinc.

Castle Hill Copper Mine, N. E., Deepwater Dn., about five miles from Deepwater.—Opened by a Newcastle Syndicate.

The following parcels of ore from this mine were treated at the English and Australian Copper-smelting Works, Waratah:—

	oz.	dwt.	grs.	
2 tons 10 cwt., yielded $6\frac{1}{4}$ per cent. copper and silver...	9	12	8	per ton.
15 „ „ 4 „ „	32	0	0	„
6 „ 0 „ „ $9\frac{1}{4}$ „ „	35	11	11	„
6 „ 14 „ „ 6 „ „	35	0	0	„

Castlerag, near Deepwater, N. E., Deepwater Dn.—A Newcastle Syndicate recently opened a copper lode a few hundred yards north from the Old Castlerag Silver-lead Mine. Four tons 2 cwt. treated at the Waratah Smelting Works yielded $2\frac{1}{2}$ per cent. of copper, and 22 oz. 8 dwt. 8 grs. of silver per ton.

Cells' Creek, H. & M., Copeland Dn.—A sample of copper ore from Cell's Creek yielded ($\frac{900}{97}$) copper 19·23 per cent., and silver 1 oz. 3 dwt. 22 grs. per ton.

Chandler River. (*See* Sunnyside Copper Mine.)

Charlton, near Oberon, B., Rockley Dn.—Mr. C. S. Wilkinson noted a quartz reef near Charlton containing carbonate and sulphide of copper, which, from its position in Silurian beds near the junction of serpentine, he regarded as likely to be auriferous.

Cheshire Copper Mine, T. & T., Rylstone Dn., three miles south of Cudgegong.—The first mention of copper ore in this locality occurs in a report by the Rev. W. B. Clarke, dated 1st October, 1852. "Indications of lead (galena) and copper occur in the quartz lodes of the ranges upon the upper portion of Lawson's Creek" (fifteen miles from Cudgegong).

In $\frac{1882}{p.\ 46}$, prospecting operations were being carried on by C. Knoblanche (about six miles from the Ilford Station on the Mudgee Railway), the shaft being about 75 feet in depth. Carbonates of copper occur at surface, sulphides at 40 feet or 50 feet. The lode has a thickness of about 2 feet, N. and S. strike, and westerly dip.

In $\frac{1882}{p.\ 60}$, the Mining Registrar reported that a large staff of men were employed, the shaft being down 120 feet, at which depth levels were being driven, the lode being 6 feet wide.

In 1885 the company suspended work, and subsequently let the mine on tribute, but work ceased entirely in 1886.

In 1897 the mine, under the name of the Rhobodah, was bailed out by I. Wall, but no work was done, as the lode was not deemed equal to representations. It does not appear that any ore was ever dispatched.

Christensen's Lode, Girilambone. (*See* Girilambone District.)

Clarence River District, C. & R., Grafton Dn.—Mr. W. Penrose, manager of Yulgilbar Station, under date July, 1898, states that the first copper lode was discovered in this district about thirty-five years ago on Ewingar Creek, Parish Ewingar, County Drake. A shaft was sunk about 30 feet on a narrow vein assaying about 20 per cent., but no ore was treated commercially. Since that date two other very small lodes have been discovered on Nogregar Creek, about four miles south of the first-mentioned, assays from which are reported up to 14 per cent.; the ground is held, but no real work is being done in the way of proving.

On Gordon Brook Station copper was found near Deep Creek, twelve miles north of Copmanhurst, some twenty-five years ago; a good deal of work was done, but the lode, though rich, was too small to pay for working. Since that date a lode has been opened, and abandoned for the same reason, at Oakey Creek, on the same run.

The above occurrences are all in, or very near, serpentine.

Mr. E. F. Pittman in $\frac{1879}{p.227}$, writing of this district, states that "after leaving Gordon Brook Station the track is over 2 miles of granite, and then again a belt of $1\frac{1}{2}$ mile wide of hard altered slates dipping west of north at an angle of 70°. In this formation occurs a lode of copper ore which has been pretty well prospected, and which, with better facilities for carriage, would probably pay to work."

Messrs. Wilkinson and Slee in $\frac{1882}{p.204}$, stated that prospecting for copper at Gordon Brook in serpentine revealed no signs of a lode, only a few small veins of copper ore of no value being met with.

The Jakoonbie Copper Mine, Pungenbar, Gordon Brook, was sunk upon to 120 feet, and driven on at the 50-foot and 110-foot levels. Mr. E. F. Pittman, $\frac{1880}{p.247}$, described the lode as being 4 feet thick and bearing N. 40° E. Sixty tons of dressed ore were smelted at Eskbank, the highest yield being $14\frac{7}{8}$ per cent. Near by Mr. Pittman examined a wide gossan lode in granite containing iron and copper pyrites, native copper, and stains of green carbonate.

A sample from Tabulam ($\frac{4690.6}{98}$) yielded 32·27 per cent. of copper, and 4 oz. 7 dwt. 2 grs. silver per ton.

In 1888 leases for copper were taken up at Yarrakalkiarra.

Coan Peak, C, Mount Hope Dn.—In $\frac{1880}{p.130}$, the Warden reported the discovery of a good surface show of copper ore at Coan Peak. (*See* Mount Hope District.)

Cobar District (*See* Great Cobar, Cobar Chesney, and Burrabungie Mines).—A theory has been promulgated in connection with flotation of certain mining properties lying south and east of the Great Cobar lode, that the deposits in them are extensions of the main lode, which have been dislocated and faulted into the positions they now occupy. This theory, however, conflicts with the readily discernible physical and geological facts. The adjacent deposits occupy planes parallel to that of the Great Cobar lode, and the individual outcrops are traceable on a true and undisturbed course. To square with the theory advanced a series of separate and distinct faultings would be necessary to account for the great disparities in the horizontal distances or "throws" between the Cobar, Fort Bourke, Chesney, and Peak lines of segregation and replacement. The absence of any disturbance or of intrusive rocks is a marked feature of the field.

In addition to the mines mentioned above, which have received separate treatment, copper ore in limited quantities is making its appearance in the lower levels of the Young Australia, Mount Pleasant, Great Western, Occidental, and Great Peak Gold Mines; but so far as development has proceeded, nothing has yet been discovered to bring them in the category of copper mines. With the exception of the Peak, the mines enumerated are all on the same line as the Cobar Chesney Mine, in which an important body of concentrating ore has been exposed to the 560-foot level; hence the possibility of workable copper veins existing in the former at lower levels, for the sulphides have only been reached in one mine, the Young Australia, and these are partially oxidised. The small quantity of copper present in the oxidised gold ores is a decided disadvantage at the present time, as it necessitates special treatment for extraction of the gold contents. The practice is to send the picked cupriferous stone to Customs Smelting Works on the seaboard, which entails a considerable cost for transport. Under the head of the Great Cobar Mine the possibility of local treatment of this class of ore will be more fully dealt with.

In the Mount Pleasant Mine cupriferous lodestuff was struck at 160 feet from the surface, consisting of carbonate, red oxide, and grey sulphide. At 180 feet the change to sulphides begins, powdery black oxide coating the only sulphide ore yet raised. According to the *Australian Mining Standard*, 22nd December, 1898, 10 tons of copper ore raised by tributors from this mine yielded 27 per cent. of copper at the Cockle Creek Smelting Works.

In the adjoining Young Australian Mine a trace of copper is showing at the lowest level attained, but sinking is not being continued at present. The auriferous stone from the oxidised zone is comparatively free from copper, cyanidation of the tailings being successfully carried on. It is estimated that about 27 per cent. of the gold contents (about 10 dwt. per ton) is extracted in the stamper battery, and 90 per cent. of the remainder by cyanide treatment.

In the Great Western Mine, further south on the same line, evidence of leaching and redeposition in the metallic state is afforded by the leafy films of metallic copper intercalated in the laminæ of the ferruginous slates forming the lodestuff. This class of ore is sorted from the battery stuff, and dispatched to the Smelting Company of Australia's Works, Dapto. The following returns are quoted from the *Australian Mining Standard* of 11th August, 1898, and a later issue:—

9 tons 15 cwt. yielded—Gold, 5 oz. 11 dwt. 8 grs. per ton; copper, 3·1 per cent.
14 tons 13 cwt. ,, ,, 4 oz. 2 dwt. 3 grs. ,, ,, 2·1 ,,

In the Occidental and Peak Mines traces of copper carbonates only have been found so far as development has proceeded.

Cobar Chesney Gold and Copper Mine, C., Cobar Dn.—This property consists of Mineral Leases 12, 19, 23, 44, 58, 61, 68, 106, and 107, embracing an area of 98 acres 0 roods 38 perches, also a freehold of 100 acres.

Originally worked as a gold-mine—the first in the field—the Cobar Chesney is now assuming considerable importance as a copper property. A large quantity of the auriferous impregnated slate from the oxidised zone was treated by battery and amalgamation for an average yield approximating to 7 dwt. of gold per ton. The tailings are estimated by careful assay tests to contain from 5 to 6 dwt. per ton; but unfortunately are mixed with copper carbonates and oxide to an extent sufficient to militate against the prospect of successful cyanidation.* The outcrop betrayed no evidence of the copper ores below; at 150 feet carbonate stainings became very marked. Sulphides began to show about 250 feet from the surface, the chalcopyrite being coated with melaconite (black oxide).

* The most favourable portion of these tailings have since been purchased by the Young Australia Mining Company, Cobar, for treatment in the Company's Cyanide Plant.

Cobar (late Fort Bourke) Gold Mine.

COBAR CHESNEY COPPER AND GOLD MINE.
(Main Shaft.)

During a recent visit the main shaft was down 460 feet, and was being continued to 560 feet (since reached). At 360 feet a crosscut through the lode revealed a thickness of 40 feet. A level has been driven 550 feet along the lode, from which two other crosscuts intersect the lode, showing its width to be persistent throughout the distance proved. Mr. H. Roberts, Mine Manager, kindly supplied the following assay values of samples obtained by chipping across the face of each crosscut through the lode:—

Crosscut, 200 feet south of main shaft—average yield, 5 per cent. copper.
,, (main) from shaft—average yield, 3 per cent. copper.
,, 350 feet north of shaft—average yield, 8 per cent. copper.

The gold contents approximate from 2½ dwt. to 3 dwt. per ton.

These samples were taken from the 360-foot level; a plat was being cut at 460 feet, and now another at 560 feet; from the increased depths it is reported that the lode is more promising than at higher levels.

Further indication of the value of the ores in the Cobar Chesney lode is afforded by the following assay determination by the Manager of the Great Cobar Mine, published in the prospectus of the Cobar Chesney Co., 1897, p. 16:—

NOTE.—All the assays are fire assays, and should be fully worked up to.

Sample.	Copper Fire Assay.	Corrected to Chemical Assay.	Gold per ton.
	per cent.	per cent.	dwt. grs.
No. 1—Carbonate from No. 3 shaft, 155 feet deep ...	2½	3·8	3 6
No. 2— ,, ,, 214 ,, ...	3	4·3	3 6
No. 3—Sulphides ,, 275 ,, ...	2½	3·8	3 6
No. 4— ,, No. 1 ,, 360 feet deep, south drive.	4½	5·8	A trace.
No. 5—Sulphides from No. 1 shaft, 360-foot crosscut	3	4·3	3 6
No. 6— ,, as mined from the whole of the lode in Nos. 1 and 3 shafts.	3	4·3	3 6

The assay value of the ore as shown in these samples is about 1 per cent. lower in copper, and almost identical in gold with the ore at present mined and treated at the Great Cobar Copper Mine.—THOMAS LONGWORTH, Manager, Great Cobar Copper Mine, Cobar, 29th October, 1897.

The carbonate ore between the 150-foot and 250-foot levels is estimated by the same authority to average about 6 per cent. of copper; and the sulphides about 20 per cent. of iron.

The sulphides occur investing slate and quartz, and though a small proportion of direct smelting ore could be hand-picked, the lodestuff is essentially a concentrating problem. Prospecting is being vigorously prosecuted in the hope of encountering more concentrated masses of sulphides at greater depths, and the levels now being driven at 460 and 560 feet should afford reliable evidences of the probability of such a wished for improvement.

Considerable interest attaches to the prospecting operations in the Burrabungie Mine on the south boundary of the Cobar Chesney, where an outcrop of ferric oxide occurs (west of the Chesney main line). A crosscut at the 200-foot level to the west under this outcrop intersects a band of iron sulphide about 10 feet thick, part solid and part mixed with the slate country; it betrays little evidence of associated copper pyrites, a regrettable, but not discomforting feature for the Chesney Proprietary, who seek abundant iron sulphide in the hope of possible pyritic or ordinary blast-furnace smelting. The mass under description probably is an isolated segregation, for a crosscut in the Chesney workings across the line of strike has failed to cut it.

Concentration is a serious though not insurmountable difficulty in such an arid tract with its low and uneven rainfall, owing to the important fact that a supply reported to equal 50,000 gallons per twenty-four hours is furnished by the mine itself, to supplement the catchment of the large storage tanks already excavated.

Failing to encounter solid bodies of fluxing sulphides, or to secure sufficient water supply for operations commensurate with the size of the lode, two alternative schemes suggest themselves, viz., utilisation of the Great Cobar slag (such of it containing excess of iron) for fluxing purposes, or co-operation with the Great Cobar Company, either by supplying picked and concentrated ore for cash value, or by smelting agreement. In either alternative the fluxing capabilities of the suitable slags or the massive sulphides of Cobar, would obviate the necessity for close concentration in the Chesney ore to remove the excessive silica. Under the head of Great Cobar Mine this subject receives further attention.

Colo Creek, B., Newbridge Dn.—Sulphide ore from Colo Creek near Newbridge has yielded ($\frac{2540}{96}$)13·6 per cent. of copper.

Condobolin Copper and Gold Mine, L., Condobolin Dn., situated about one and a half mile northerly from Condobolin.—Opened about two years ago to a depth of 90 feet, under Government aid, in schistose country. The vein has a thickness of from 12 to 15 inches at surface, and 4 inches at 50 feet, and strikes N. 40° E., with a dip S. 50° E. It consists of ferruginous quartz with a little copper carbonate and grey sulphide. Six tons raised during operations yielded 11 per cent. of copper and a trace of gold at the Australian Smelting Company's Works, Dapto. About a quarter of a mile west copper ore was discovered and followed down 90 feet. Vein reported to have been 2 feet thick at surface, but pinched out at 90 feet.

Traces of copper also occur in Shepherd and Party's Mine to the north-west on the Melrose Road; it makes its appearance in the schist country.

Congwarra, T. & A., Queanbeyan Dn., at the junction of the Cotter and Paddy's Rivers, in Portion 20, Parish Congwarra, County Cowley, about twenty-seven miles from Queanbeyan.—Copper ores occur in this locality in a bed of limestone, in granite country. The limestone has an apparent N.E. and S.W. strike. The deposit on Portion 20 has been prospected to a small extent by open cuts and a tunnel. Sulphides associated with a hornblendic rock are exposed in the tunnel, but not in payable proportion. The outcrop shows abundance of iron oxide from alteration of pyrites, and stainings of copper carbonates. This deposit is worthy further prospecting on account of the great width of the outcrop.

Other deposits occur higher up Paddy's River. The Under Secretary for Mines in $\frac{1895}{\text{p. }61}$, states that from Coyle's Mine 60 tons of ore were raised, yielding copper to the value of £150 and silver to £105; but it is not certain whether it is identical with the lode under description.

Conrad Mine. (*See* Borah Creek.)

Coolac, L., Gundagai Dn.—Copper ore from five miles N.W. of Coolac yielded ($\frac{1684}{97}$) 3·44 per cent. of copper.

Coolah, M., Cobbora Dn.—Copper sulphide from Pine Ridge, near Coolah, yielded 23 per cent. of copper.

Coombing Park Copper Mine, B., Carcoar Dn., about two miles S.W. of Carcoar.—After the failure of the Belubula Copper Mine (opened in 1845), the mining captain, Mr. Reed, proceeded to open the Coombing Park lode for the late Mr. T. Icely, the date being probably prior to 1850, for in April, 1851, the first Geological Surveyor—Mr. S. Stutchbury—reported that the lode had been opened to some extent. The report is valuable as the only one extant on this property. Of the mine Mr. Stutchbury wrote:—

"Its geological position is upon an 'elvan' course in greenstone slate with occasional bands of clayslate; compact hematite iron with magnetic brown oxide of iron compose the 'back of the lode'; standing above the grass the strike or level course is N. 28° W., underlaying to the eastward at an angle of 61." The shaft was sunk perpendicularly 10 fathoms, when it touched the footwall of the lode, which exhibits 'slickensides,' killas backed by elvan; at this point a 'plat' was formed, and a 'drift' cut across the lode to the extent of 30 feet. It is not satisfactorily known whether the 'headwall' or 'hanging wall' was reached. The shaft was then turned down vertically on the drift. The angle has since been cut away, and the and the back filled in; it now proceeds on the incline of the underlay.

"A plat 15 feet x 12 feet was cut at 16 fathoms; in this plat a 'slide' or 'fault' has shifted the metallic run of the lode 4 feet to the eastward. At this point some very encouraging evidences occur. There has not been any driving on the level course or drift, but merely an extension of the plat.

"At 20 fathoms a level course has been worked 31 feet to the northward and 33 feet southward. The level is 3 feet wide and 6 feet high. A cross-drift 27 feet in length has been made opposite the shaft, at which place the miners pronounce the headwall to be; this is not proved.

"At the north end of the level there is a considerable quantity of soft 'killas,' the joints and laminations of which are filled with beautiful vermillion red oxide of copper 'chalcotrichite' minutely crystallised. This appears to accompany the line of strike or fault. Upon driving about 4 feet in drift the face of the slide was observed. The shaft has been sunk 10 fathoms below. At 30 fathoms water was cut into; at present it is easily kept under by the 'kibble.'

"Of the lode itself, it will be evident by the description of the workings on level courses, and on drift across the course, that there are 30 or more feet between the two rock walls."

The mine appears to have been abandoned for a number of years prior to 1876, when Messrs. Samuel and Lloyd reopened it and erected smelting furnaces, one being in blast during that year. Operations were continued during 1877, but in the following year, after considerable unremunerative expenditure, the mine was handed over to the owner, Mr. Icely, who carried it on for a couple of years longer. The main shaft was sunk about 150 feet, and the lode driven on for a considerable distance. It is reported to have been very patchy, the ore bunches sometimes having a thickness of 1 foot or over.

During a recent visit to the site a sample was selected from the old tip consisting of ferruginous carbonates of copper with garent rock, for the purpose of testing it for the presence of gold. A trace only was found (under 2 dwt. per ton).

A short distance from the mine on the same estate excellent iron ore is now being quarried and dispatched to the smelting works at Dapto and Cockle

Creek. At the time of inspection a face 20 feet deep was exposed in one of the outcrops in solid brown hematite, averaging about 52 per cent. of metallic iron, according to Mr. Links, who is mining it. The Mining Registrar reports that about 5,000 tons were dispatched during 1898.

Mr. Stutchbury in 1851 was much impressed with the iron resources of the estate, and wrote: "In the great park at Coombing the summits of five small mountains or hummocks (of from 20 to 50 or more acres each) are composed of a very rich compact hematite iron, much of it magnetic.

"A similar ore of iron forms the back of a copper lode on the same estate.

"The apparent quantity of iron is so immense, and if all things else were compatible with manufacture of iron, there is sufficient to supply another Sheffield for ages to come. At the present time I would suggest the examination by shaft or level of the interior of one of these mounds, as it is possible that the iron may be laying on the back of a 'room,' or the cross junction of metallic lodes of higher commercial value than the iron.

"Near Mr. Icely's residence, in one of the paddocks, a copper lode has been discovered and opened to some extent, but not more than was necessary to demonstrate its capabilities. In comparison with those I have examined in this Colony it certainly is of high promise."

Mr. Stutchbury's suggestion of testing the iron outcrops at a depth in search of more valuable metals, has never been attempted. Situated in a cupriferous locality, close to a copper lode, capped originally with similar ore, renders testing very advisable. It is reported that a trace of copper was detected on a block of iron from the present workings; but this may have been iridescent tints of oxide of iron, which frequently are mistaken for peacock copper ore. So far as the Writer's examination extended in the open quarries, no trace of copper had yet been revealed.

Cooma Mining Division, T. & A.—Under date 28th July, 1898, the Mining Warden supplied the following list of copper-bearing lodes in his district:—

Owner, A. Sturgeon, Parish Jindabyne.—Not being worked.
,, — Reynolds ,, Seymour, about two miles southerly from Adaminaby.—Not being worked.
,, — Inglemann, Parish Bunyan, County Beresford.—(*See* Dartmoor.)
,, T. Goodman ,, Montague ,, ,, (*See* Skidmore and Party.)
,, Executors late Mr. Harnett, Parish Umeralla, County Beresford.—(*See* Hayes, Jennings, & Co.)
,, W. Jardine, Parish Bunyan, County Beresford.—(*See* Nitholm Mine.)
,, H. Dyball ,, Arable ,, ,, Not worked.
,, Fergusson Bros., Parish Montague, County Beresford, seven miles east of Cooma.—Not worked.
,, C. Solomon, Parish Cootralantra, County Beresford, fifteen miles westerly from Cooma.—Not worked.
,, Britten and Weigall, Parish Umeralla, County Beresford, on Fergusson's land.—Not worked.

Mr. G. T. Litchfield, of Matong, states that near Buckley's Crossing, on the right-hand side of the Snowy River, between the junctions of the Boloco and Bobundra Creeks with the river, the granite country is traversed by several large quartz reefs, heavily charged with pyrites and oxide of iron. In several places the reefs are stained with malachite, and good specimens of both malachite and chalcopyrite are obtainable. These reefs strike E. and W., and can be traced for several miles.

About thirty miles further down the river, between the entrances of the Matong and Paupong Creeks, in slate country, a large quartz lode occurs on the right-hand side of the river, carrying fluorspar, baryta, copper pyrites, and malachite, and about 4 dwt. of gold per ton. The outcrop is traceable for about one mile on an E. and W. strike. From a leader about 9 inches wide, in the middle of the lode, Mr. Litchfield made several assays, which averaged 11 per cent. of copper, 32 per cent. of lead, and 24 oz. of silver, and 4 dwt. of gold per ton. Within a radius of about two miles from this reef several outcrops showing copper ores occur. The country is rugged and little prospected.

Conjola Creek, S., Ulladulla Dn., Parish Little Forest, County St. Vincent.—A little copper ore occurs in highly-altered rocks in the bank of Conjola Creek, near its head. The outcrop is but a few feet in length, and the dip is under the bed of the creek, which is a permanent stream. The ore consists of refractory iron and arsenical pyrites, with chalcopyrite. At the outcrop a little carbonate stainings occur, but are merely superficial. Assays of selected samples show very little copper and but traces of gold and silver.

Cooperacurripa Copper Mine, P. & U., Walcha Dn., near Nowendoc.—Lode in main shaft reported to be 4 ft. 6 in. thick at 45 feet, and the ore improving from 8 to 14 per cent. Another shaft on a reported 14-foot lode offers very fair promise.

An application for a lease of 80 acres for copper-mining at Walsh's Creek, near Nowendoc, in 1883, is probably identical with the above.

Cootamundra, L., Cootamundra Dn.—A sample of carbonate ore from five miles from Cootamundra ($\frac{781}{94}$) yielded 12·8 per cent. copper; and another from 8 miles N.W. ($\frac{4710}{95}$) yielded 16·80 per cent.

On J. Kearn's private land, about six miles westerly from Cootamundra, and about one mile from the Cootamundra-Temora Road, in the parish of Dadauman, county Bland, a copper lode occurs.

To Mr. T. Hingerty, Temora, the Writer is indebted for the following particulars:—"The outcrop is not well defined, being mixed through the granite, forming a thickness of about 2 or 3 feet. A shaft, about 60 feet deep, sunk a few feet from the outcrop, evidently cut the lode, as a good deal of copper ore was brought to the surface." A sample forwarded by Mr. Hingerty, as representative of the ore at surface, was of very low grade.

Cootra Copper Mine. (*See* Nuntherungie.)

Cootralantra Copper Mine, T. & A., Cooma Dn. on a freehold fifteen miles westerly from Cooma Railway Station.

The lode is reported traceable for about 2 miles on a N. 70° W. strike; three shafts have been sunk at various distances along the lode to depths of from 100 to 130 feet. In the "Vercoe" shaft the lode was reported by R. Goodfellow, for the owner, C. Solomon, Cooma, to have a thickness of from 2 to 3 feet from the 40 to the 109 foot level, and to carry yellow sulphide. Driven 47 feet at the last level.

In the "Old Tom" shaft, which is 107 feet deep, the lode is reported as about 4 feet thick, the centre 2 ft. 6 in. of which carries good ore, with poorer ore on the walls, which are well defined in granite.

The outcrop consists of gossan with quartz and oxides and carbonates of copper. Parallel lodes occur, but have not been prospected.

The prospecting shaft was sunk 600 yards from site of first discovery; about 300 feet separates the three shafts from each other.

Twenty tons of ore sent to London realised 13¾ per cent. of copper.

Cope's Creek, P. & U., Tingha Division.—Near the junction of the Gwydir River and Cope's Creek a sample of lodestuff carrying galena, malachite, and sulphides of iron and copper yielded ([illegible]) 7·08 per cent. of copper; and 59·69 per cent. of lead.

In the *Australian Mining Standard* of the 6th May, 1897, it was announced that a copper lode was discovered near Boggy Camp Diamond Mines, showing carbonates at surface.

Copper Blow Copper Mine, Barrier Range, A., Broken Hill Dn.—Copper ores from this mine were exhibited at the Melbourne Centennial Exhibition of 1888, but no particulars are available.

Coppabella, T. & A.—Copper ore is reported to occur in the Parish of Coppabella, County Goulburn.

Copper Creek, Copper Mine Creek, L., Canowindra Dn., Parish Malongulli, County Bathurst.—This creek is a tributary of the Belubula River, and drains from Sugarloaf Mountain, in the same parish, near which the Sugarloaf, Smith and McGuinness's, and Rothery's Mines occur. The cupriferous formation is an andesite, and in one mine—Smith and McGuinness's copper carbonate and native copper occur in the steam holes of the rock, which are now chiefly represented by calcite amygdaloids.

Copper Hill Copper Mine, about two miles south of Molong, B., Molong Dn.—This was one of the first—if not the first—copper mines opened in New South Wales, its early discovery being doubtless due to its exposed situation close to the old Sydney to Dubbo Road, which passed by the side of the hill, where the characteristic green and blue colourations of copper carbonates are still visible in the remaining portions of the rugged outcrop.

Mr. James Ranken, of Bathurst, states that he saw mining operations in progress in 1845. In 1847 a company was formed to work the lode—Mr. (now Sir Saul) Samuel being managing director. Shafts were sunk 70 and 146 feet and smelters erected. A quantity of ore was converted into regulus and carted to Sydney, but no records of the amount are available. The company ceased operations in 1851 when gold was discovered. In 1852 Geological Surveyor Stutchbury reported the mine as "deserted and not accessible." He described Copper Hill as consisting of "elvans" and decomposed clayslates, followed by porphyries, with occasional altered slates, until it joins the granite of Molong mentioned in his former reports. The following information was derived from a Mr. Clymo, formerly manager of the mine. He first describes "Hood's" shaft to be 21½ fathoms (189) feet deep; the first vein or bunch of ore was struck at 45 feet; it consisted of green and blue carbonates with red oxides; this shaft was driven 180 feet north. The first shaft was sunk alongside a smooth slickensided wall on which were found strings of native copper. Another level or cross-drift was cut 60 feet east, when a lode of quartz and ore was found 9 feet wide, and dipping to the east at an angle of about 20 degrees. Some unsuccessful attempts at smelting had been made, the failure of which Mr Stutchbury attributed to probably the unsuitable open-mouthed furnaces adopted.

In 1871 the Molong Consols Copper-mining Company was formed, according to local report on the strength of statements of the large amount of ore available at grass. Three reverberatory furnaces were erected, but only one was charged; but it is evident from its internal and external condition no regulus or refined copper was produced. Practically little prospecting was done by this company beyond surface work.

In $\frac{1886}{p.130}$, C. S. Wilkinson, late Government Geologist, visited Copper Hill, and described it as a huge mass of felsite, with hornblende porphyry in places, traversed by numerous lodes or dykes of porous ferruginous quartz. In connection with the latter, it is interesting to note that the late Mr. J. E. Kelly, on whose estate the hill occurs, submitted 14 tons from it and neighbouring outcrops to battery treatment for a return of 4 dwt. of gold per ton. A sample of the copper ore lying at surface was selected by the writer, but yielded under 2 dwt. of gold per ton by assay.

About 1888 a Newcastle Syndicate carried on a little surface prospecting higher up the hill.

A good deal of copper carbonate is mixed in the fines and screenings from the old workings, but their copper contents are not recoverable by furnace methods, as mechanical separation of the siliceous waste is not possible; leaching alone could effectively treat this material. The outcrop has a very deceptive appearance at a distance, owing to the strong blue and green colourations in sheltered crevices and excavations, arising from the internal leaching of the thinly-distributed copper ores and redeposition in the form of sulphates and carbonates in sheltered spots by evaporation of the percolating solutions.

Copper Mountain, Dundundah River.—In 1852 the Rev. W. B. Clarke noted the occasional occurrence of copper in the detritus on the summit and eastern slopes of the Great Dividing Range not far from the source of the Dundundah River.

Cordillera Hill, B., Tuena Dn., Parish Tuena, County Georgiana.—The Cordillera Hill Silver-mining Company, which started operations during the silver boom of 1888, extracted 222 tons of copper from their silver ore during that year. The exact figures, according to the Warden, $\frac{1888}{p.68}$, being: 9,000 tons of ore treated, yielding 82,800 oz. of silver, 404 oz. of gold, 227 tons of lead, and 222 tons of copper, valued at £37,343.

The kindly gossan ores of the outcrop at Cordillera, just as those of the neighbouring Mount Costigan and more distant Lewis Ponds and Sunny Corner Mines, gave place at water-level to refractory mixtures of sulphides of zinc, lead, iron, copper, and arsenic, of low grade, which so far have baffled every attempt at profitable working, especially since the serious fall in silver value.

It is noteworthy that scheelite (tungstate of lime) and stolzite (tungstate of lead) occur in the Cordillera Mine.

Cornish Copper Mine, P. & U., Barraba Dn., Gulf Creek, about twenty miles N.N.E. from Barraba.—In 1896 the Cornish Company received aid from the Prospecting Vote, by means of which it was successful in opening out payable ore, which, during that year, realised sufficient to cover current expenses, in addition to the cost of extensive developmental works.

Warden Stevenson, under date 11th July, 1898, stated that the lode has been tested to a depth of about 90 feet by three shafts, and can be traced on the surface for a considerable distance. Haulage was by steam-power, and smelting by water-jacket furnace. An excellent dam conserves a sufficient water supply. A considerable quantity of ore has been treated locally, converting it into regulus, in which form it was despatched to the English and Australian Smelting Works, near Newcastle.

Under date 26th July, 1898, the Secretary of the company stated that the mine had been idle since October, 1896. During the previous nine months 800 tons of ore were raised and smelted in a reverberatory furnace at the mine. Some 200 tons in addition, which had accumulated during the previous two years' prospecting operations, were treated in a water-jacket furnace, but owing to lack of experience in this form of furnace, the result was not altogether a success. There is a complete plant at the mine, and about 9,000,000 gallons of water conserved in a large dam. Since the beginning of the present year the mine was let on tribute; but quite recently all interests passed by purchase to the Mining and Financial Trust Syndicate, Ltd., 6, Draper's Gardens, London, and active mining and smelting operations will shortly be in progress.

Cornish Settlement. (*See* Carangara.)

Cow Flat Copper Mine, B., Rockley Dn., about five miles from George's Plains Railway Station.—According to Captain W. R. Reynolds, the first ore raised from Cow Flat was shipped to England. The earliest official record is contained in the Annual Report of the Department of Mines for 1875, p. 59. At that time eighty men were employed, and a statement is made that the yield had not decreased during the past twelve months, considering the number of men employed. Six furnaces had been erected, but only two were in use, owing to the sheds being leased to the Esk Smelting Company, who reduced the ore to regulus, and forwarded the latter to their refining works at Lithgow.

In 1872 the mine was floated into a public company by Mr. S. L. Bensusan.

In $\frac{1877}{\text{p. }201}$ the late Government Geologist, Mr. C. S. Wilkinson, reported that "the general formation of the Cow Flat District consists of Silurian sandstones, shales, limestones, and talcose, chloritic, and micaceous schists, traversed by numerous quartz reefs, some of which are of great thickness, and termed by the miners 'blows.' The general strike of the strata and reefs is N. 25° W., dip easterly, though near Bell Creek they strike N. 30° E., and dip westerly. Copper ore occurs in many of the reefs. The green and blue carbonates of copper are generally found near the surface, and passing downwards the black oxide, or 'coated' ore, is met with, and below this the grey and yellow sulphurets with galena; occasionally the red oxide and a little native copper are found. The irregular and uncertain mode of distribution of these ores is the chief cause of so much fluctuation in the copper-mining industry of the district."

In $\frac{1878}{\text{p. }97}$ the Mining Registrar reported that thirty men were constantly employed during the year, 80 to 100 tons of ore per month being raised of an average value of about 8 per cent., which was disposed of to the Esk Smelting Company at about 60s. per ton. Depth of shaft, 180 feet; lode, from 6 inches to 10 feet in thickness.

In $\frac{1879}{\text{p. }72}$ the work performed was not equal to that of former years, owing to the low price of copper. About 220 tons of ore were raised, which yielded 20 tons of copper, valued at £1,100.

In 1880 the mine was leased to Mr. Lewis Lloyd. A new shaft was sunk 72 feet, about 400 yards from the old workings; the result, however, was not as satisfactory as expected, the lode was well defined and 2 feet thick, but the grade was low. Three hundred and seventy-six tons of ore were raised during the year, and sold to the Bowenfels Smelting Works for £813.

In 1881 three new shafts were being sunk. The deepest level in the mine was 180 feet. Three hundred and eighty-seven tons of ore were raised, and sold for £876 17s. 3d. Being smelted at Lithgow, it yielded 28 tons of copper, valued at £1,620.

The Cow Flat lode has a very strong iron outcrop, which doubtless induced hopes of good things below, unfortunately not to be realised so far as testing has proceeded. The lode, judging from the outcrop, practically consists of hornblende and chlorite schists impregnated with iron and a little copper pyrites, which under atmospheric influences have become converted into iron oxides and copper carbonates for shallow depths only, for the unaltered sulphides are visible in the open cuts. A sample of the unaltered pyrites selected from one of the shaft tips during a recent visit yielded 5·20 per cent. of copper and a trace of gold (under 2 dwt. per ton).

This property has recently been floated into an English company, and its early reopening is expected. A thorough test is requisite before the real character of the lode can be ascertained.

Cowra Copper Mine, B., Cowra Dn., Bald Hill, three and a half miles west of Woodstock.—Opened about twenty-five years ago in andesite. Shaft sunk to a shallow depth; no payable ore obtained; the country outcrops hereabouts are stained with carbonate of copper from decomposition of particles of native copper in the mass of the rock.

Cowra, L., Cowra Dn. (*See* Broula and Neila Creeks.)

In 1882 a number of leases for copper-mining (thirteen) were taken up in the Cowra District, but were abandoned during the same year.

Cullen's Creek, N. E., Wilson's Downfall Dn., near Rivertree.—A find of argentiferous copper ore has recently been made at Cullen's Creek. At surface the ore consists of gossan, which passes below into a mixture of copper and iron pyrites, galena, and blende. No particulars of the size of the lode have yet come to hand, but it is understood to be small. An assay of a sample forwarded through Mr. J. B. Jaquet, Geological Surveyor, yielded 19·23 per cent. of copper, and 37 oz. 13 dwt. 12 grs. of silver, and a trace of gold per ton. Later samples yielded—$\frac{1867}{98}$, and $\frac{1961}{98}$, copper, 23 to 30·7 per cent.; silver, 98 to 134 oz. per ton.

Cullerin, S., Goulburn Dn.—Mr. Jaquet reports that on M.L. Portion No. 1, Parish Millbank, two miles from Cullerin Railway Station, a shaft has been sunk 30 feet in light blue slates, slightly impregnated with copper carbonates. The shaft is situated close to a large outcrop of ironstone; but the copper ore has not been proved to occur under the ironstone, though an assay ($\frac{154}{99}$) from the ironstone outcrop yielded a trace of copper (less than 0·5 per cent.).

Currandidgee, head of Little River, Yass District.—Mr. Engellen, of Gundagai, reports a large cupriferous lode in this locality, about 20 feet wide, with an assay value of about 7 per cent., opened only by a shaft 40 feet deep. Lode traceable for a considerable distance on surface.

Currowong Copper Mine (afterwards the *Phœnix*), S., Goulburn Dn., near Lake George, twenty-two miles from Goulburn, and thirteen from Bangalore Railway Station.

The copper lode worked in this mine was discovered by the presence of characteristic ores in the outcrop, samples from which assayed at the Sydney Mint at the rate of 27·90 per cent. of copper, 10·79 per cent. of lead, and 9 oz. 16 dwt. of silver per ton. The first shaft was sunk through gossan, various assays of which yielded from 11 to 14 dwt. of gold, and 5 oz. of silver per ton.

In 1865 a company was formed to work the deposit, under the title of the Currowong Copper-mining Company, capital £60,000, in £1 shares, having obtained the mine by purchase from the prospectors.

The first report of the company was issued on the 31st December, 1866. From it it appears that a well-defined lode was discovered soon after the company entered into possession, but it had to be followed down some depth before ore was obtained of sufficiently good quality to justify transit to Sydney.

During the last four months of the period mentioned, about 1,000 tons of 14 per cent. ore were forwarded to Sydney. This amount—less a small parcel sent to England—was delivered to the Newcastle Smelting Works for treatment, from a part of which 44 tons of refined copper were produced during the preceding few weeks. A large sum was expended in machinery for the mine. The carriage of ores and machinery formed a heavy item in the expenditure, as the railway had not then reached Mittagong. A dividend of 10 per cent. was announced after writing off £7,218 for preliminary expenses and carrying to profit and loss account £2,245.

In the third half-yearly report ending 31st December, 1867, it is stated that the first smelting operations had not, so far, proved satisfactory, chiefly—according to the manager—on account of the "refractory nature of the ores and the inferior quality of the imported firebricks."

Local firebrick, manufactured on the property, however, answered every test.

The lode at 90 feet was reported to be 26 feet wide. At 162 feet, 15 feet of lode-matter had been exposed without revealing the hanging-wall. The length of proving along the lode was 325 feet.

The following shafts had been sunk:—

Mitchell's shaft, depth 168 feet	... ...	135 feet through lodestuff.
Wolfskehl's ,, ,, 77 ,,	... ...	Average width of lode in these workings reported fully 15 feet.
Bell's ,, ,, 66 ,,	... ...	
Engine ,, ,, 76 ,,	... ...	

During the half-year 1,100 tons of ore were raised.

In the fourth half-yearly report six furnaces were stated to be in full work, reducing the ore to regulus, in which form it was found more profitable to dispatch it than to attempt refining at the mine. Contracts were entered into with the smelters to convert 5,000 tons of ore into regulus by the end of October ensuing, and to erect additional furnaces. About 2,500 tons of ore were handed over to the smelters during the half-year.

In 1869 the company was wound up, and in 1872 reformed as the Phœnix Copper-mining Company.

A progress report of the latter, dated 30th January, 1872, states that the mine had fallen into the hands of the mortgagees of the Currowong Company, who leased it to some of the former employees working co-operatively. The operations of the latter are reported to have yielded about 450 tons of copper or its equivalent, which gave a net dividend of £18,000. Mr. Holman, reporting for the Phœnix Company, stated that during the previous eleven months a party of six miners (shareholders), in conjunction with Deer & Co., had extracted, in round numbers, about 4,000 tons of ore, from which 298 tons of copper had been smelted, 560 tons of regulus and ore sent to Newcastle, leaving about 700 tons at grass. The ores sent to Newcastle are stated to have averaged 12 per cent.

In the second half-yearly report of the Phœnix Company 82 tons 12 cwt. 1 qr. 14 lb. of fine copper are stated to have been produced, as compared with 135 tons for the previous half-year. In mining all the ore was being taken out, for it was found that during the operations of the working shareholders after suspension of the Currowong Company only the best ore was picked out—an evil only too likely to occur under such conditions in the absence of supervision; temporarily rich returns may thus be made at the expense of systematic mining—in fact, at the ruin of the mine.

No further particulars are available of the operations of the Phœnix Company, but Mr. D. H. Thomas, head smelter of the Girilambone Copper Mine, states that he and others worked on tribute in the "new lode," about 500 yards from the first-discovered deposit, when the Phœnix Company held possession, this being the last work carried on under its ownership. Mr. Thomas stated that the ore raised during the tribute averaged about 4½ per cent. copper. In the bottom of the workings the lode was 30 feet wide and of an average value of about 3 per cent. The matrix is stated to be solid pyrites, which is an important feature in view of the possibilities of pyritic smelting.

In 1896 a company under the title of the Currowong Copper and Gold Mining Company (Limited) was formed to open up the mine. The earliest workings were unwatered and cleaned out and prospecting drives put in, but the results were not encouraging, and the enterprise was abandoned when the limited capital was expended. The "new lode" referred to by Mr. Thomas was not reopened.

In $\frac{1880}{\text{p. 50}}$ three samples of water from the Currowong Mine were analysed by W. A. Dixon, F.C.S., F.I.C., with special reference to their poisonous action on the fish in Lake George, and were therefore only examined with regard to the metals in solution. The metals were present as sulphates, and are stated below as anhydrous salts:—

	From Currowong Creek.	From Working Shaft.	From Old Shaft.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
247. Sulphate of copper ...	1·12	17·67	6·42
" zinc	16·98	53·54	7·20
" iron	·43	1·42	·98

Currowong Copper Mine, T. & A., Delegate Dn., situated on Currowong Station, at the east end of Black Jack Range, Parish Currowong, County Wellesley.—This mine was discovered about eighteen years ago and subsequently opened by H. T. Allen, of Delegate, to a depth of 30 feet. The ore-vein was reported to have had a thickness of 1 foot at surface. At 30 feet it consisted chiefly of clay, with grains of native copper. Two tons of ore dispatched at the time to Sydney are reported to have yielded 10 per cent. of copper and a little gold. During 1898 the writer visited the locality; operations for reopening had just begun on behalf of Victorian investors. Traces of copper occur over some little distance in granite, but no evidence of a defined ore-body was revealed in the shallow openings so far excavated.

Dandaloo. (*See* Woodlands and Albert Waterholes.)

Dartmoor Copper Mine, T. & A., Cooma Dn., situated on Portion 135, Parish Bunyan, County Beresford, about four miles south-easterly from

Cooma Railway Station.—The main lode occurs at the junction of felsite and Silurian slates, with limestone in close proximity. The ore occurs in the soft rotten slate at the junction.

The mine was originally opened in 1888. In 1897 attention was again given to it, a shaft being sunk 54 feet, crosscut at bottom 20 feet, driven and stoped 30 feet from 23-foot level to surface. The average thickness of lode-stuff from which the ore was picked is about 4 ft. 6 in. Strike, north and south; dip, west at 56 degrees.

In the shaft a crosscourse about 8 inches thick was encountered.

During the above operations about 36 tons of ore were sent to smelting works, with the following returns*:—

	tons.	cwt.	qrs.	lb.	Smelting Works.	Yield.	Value. £	s.	d.
Jan., 1897 ...	10	0	0	0	Walleroo	Copper, 10 per cent.......... Silver, 36 oz. per ton	91	18	3
Aug., 1897 ...	6	6	3	11	Smelting Co. of Australia.	Copper, 14·70 per cent. ... Silver, 49 oz. per ton	76	6	9
Oct., 1897 ...	5	0	2	2	do ...	Copper, 16·9 per cent. ...... Silver, 36 oz. 13 dwt. 19 grs. per ton	61	11	6
Dec., 1897 ...	6	6	1	14	do ...	Copper, 11·5 per cent. ...... Silver, 19 oz. 1 dwt. 16 grs. per ton	48	18	11
Feb., 1898 ...	6	0	0	0					
							£278	15	5

The Dartmoor East Block Proprietary are prospecting another lode known as the "East Lode," close to the main lode. It occurs in quartz porphyry close to the junction with limestone, and strikes north 50 degrees west. The outcrop is largely quartz, and of considerable width. At the south end of the main outcrop about 4 feet of lodestuff has been exposed in a shallow opening, from which assays have yielded up to 10 per cent. copper and 12 per cent. lead. Shaft being sunk under aid from the Prospecting Vote; at 64 feet heavy water encountered, necessitating erection of horse-power haulage. Shaft passing through ironstone with copper veins mixed with limestone.

Deepwater District, N. E., Deepwater Dn. (*See* Castle Hill Mine.)
In 1885 samples from near Deepwater, consisting of iron and copper pyrites, yielded from 12 to 14·35 per cent. of copper, and 10 to 31 oz. of silver per ton. Ore from five miles north ($\frac{4486}{95}$) yielded 8·49 per cent. copper, and 20 oz. 15 dwt. 22 grs. silver per ton; $\frac{4124}{97}$ yielded 17·87 per cent. copper, and 32 oz. 1 dwt. 8 grs. silver per ton; $\frac{2885}{98}$ yielded 16·60 per cent. copper, and 18 oz. 1 dwt. 12 grs. silver per ton.

Delaney's Dyke, L., Molong Dn.—In $\frac{1886}{p. 133}$ Mr. C. S. Wilkinson reported that at Delaney's farm altered Silurian limestones and chloritic rocks occur dipping west at 75 degrees; in these rocks a little grey sulphide and carbonates of copper were noted, but not in payable quantity.

* Supplied by Mr. A. L. Cadogan, Manager.

In $\frac{1888}{\text{p. }183}$, Mr. Anderson described Delaney's Dyke as a garnetiferous rock containing gold and copper. It traverses Silurian slates near their junction with granite; strikes nearly north and south, and dips east at a high angle. Numerous shafts were sunk in the outcrop, the deepest 65 feet. The lode at 40 feet averages 10 feet; at 55 feet it reaches 23 feet, including a "horse" of dark slickensided slate stained with carbonates of copper. At the south end of the deepest level the lode was reported rich in copper carbonates.

Denison Town, M., Cobbora Dn., Talbragar River.—In 1888 a copper lode in slate country was opened by Messrs. Wall and Lynch during the copper boom of that year, near the south-west boundary of Pine Ridge Station. Outcrop traceable for about 20 chains, but very narrow, striking about north and south. Opened to about 18 feet. Twenty-eight tons of carbonate and grey ore sent to the Newcastle (Waratah) Smelting Works reported to have yielded nearly 15 per cent. copper. The site has recently been taken up by Mason and others of Leadville.

Diamond Jubilee Mine, A., Broken Hill Dn., twenty-three miles north of Silverton.—A company was registered in 1897 to work this property. Shaft sunk 67 feet. A 20-ton trial of the ore reported to have yielded 19 per cent. of copper, and 17 dwt. of gold per ton.

Mr. Hebbard, Inspector of Mines, who examined this occurrence in 1898 (Pros. Papers 98–4,590), states that it occurs close to Para Creek, about one mile west of Yuba Silver Mine, in the Parish of Robe, County Yancowinna, and described the locality in the following terms:—"There are evidences of abundance of ore all over the property, but so far it does not seem to make down. The ore deposits have been opened in forty or fifty places on the property, and everywhere have proved copper and gold bearing. Parcels of picked ore have yielded up to 2 oz. of gold per ton, and 24 per cent. of copper, and several tons of this class of ore have been disposed of."

Mr. Hebbard was of opinion that there was a great quantity of ore on the surface that would pay to concentrate.

At a later inspection no defined lode had been proved. A shaft had been sunk 60 feet in one deposit—ore was visible at 20 feet, but none at bottom.

The ore consists of copper-stained, gossany quartzite, and invariably contains gold associated with the copper. Aid granted to further prospect.

Doctor's Copper Lode. (*See* Bungonia.)

Drake, N. E., Fairfield Dn. (*See* Mount Carrington.)

In $\frac{1888}{\text{p. }109}$, the Warden reported a very rich lode of copper running through some of the leases at Drake; 20 tons of ore from a 4-foot lode treated at the Waratah Smelting Works yielded 21 per cent. of copper. The ore consisted of carbonates and sulphides, and carried a little gold.

At Sawpit Gully, two miles north of Drake, Mr. C. S. Wilkinson reported in $\frac{1889}{\text{pp. }199 \text{ \& } 200}$ that an auriferous copper lode was being worked. He also mentioned copper pyrites in the auriferous lodestuff at Red Rock, nine miles northerly, and Long Gully, seven miles south of Drake. At the Great Northern Mine a lode 2 feet to 4 feet wide had yielded copper to the value of £14, and gold to nearly £4 per ton from a parcel of 30 tons sent to the English and Australian Company's Waratah Works. From the Nil

Desperandum Mine 3 tons 15 cwt. of ore yielded about 33 per cent. of copper. Under the heading of Mount Carrington will be found the latest phase of the copper industry at Drake.

Elsmore, P. & U., Inverell Dn.—In the Newstead tin mine near Elmore, copper, iron, and lead sulphides assayed, $\frac{2795}{95}$ and $\frac{2796}{95}$, for 7·15 to 7·29 per cent. of copper.

Emmaville, N. E., Emmaville Dn. (*See* Bald Nob.)—Copper and copper ores have been reported from several localities in the Emmaville District, but no lodes have yet been worked to any extent, so far as is known, other than the Bald Nob Mine. At Hall's Grampians, Portion 600, Parish Strathbogie North, Mr. T. W. E. David reported* "Reid's copper lode" as the principal copper vein seen by him in the district. The lode, a breccia vein, resembling the Little Plant silver lode, is from 1 to 3 feet wide, strikes 16° N. of E., dips S.E. The vein stuff is chiefly chlorite with a little quartz containing blue and green carbonate of copper. The country is dark thickly-cleaved claystone.

Copper occurrences are also reported at Little Plant Creek, Pye's Creek, Glen Creek, and the Ottery Lode. In Portion 85, Parish Strathbogie North, a vein of cellular quartz about 2 feet? wide strikes N. 40° E. The veinstuff shows streaks of blue carbonate and a little black oxide of copper.

In Portion 2, Parish Paradise North, County Gough, the same authority mentions the occurrence of a vein of fluorspar, copper carbonate, and iron oxide striking 20° N. of E., and dipping northerly. The portion containing the copper carbonate, is 4½ inches wide.

Grey copper ore, Tetrahedrite, containing from 400 to 1,100 oz. of silver per ton, occurred in the silver lodes at Little Plant Creek and Pye's Creek.

The following analysis by the Government Analyst shows the composition of the argentiferous grey copper:—

In 100,000 parts.	
Metallic copper	31·500
" antimony	18·130
" zinc	6·140
" iron	6·440
" lead	·680
" silver	1·635†
Sulphur	26·180
Insoluble in acids (silica)	7·200
Traces of arsenic, gold, undetermined	2·095
	100 000

Essington Copper Mine, B., Rockley Dn., Native Dog Creek, ten miles west of Oberon, on road to Rockley.—This mine was probably opened about 1872. G. Maliphant, of Girilambone, who erected furnaces at the Essington Mine in 1873, states that good sulphide ore was then being obtained. The necessary fireclay for the furnace, obtained from Swallow's Nest, formed very good firebrick.

* Vegetable Creek Tin-mining Field, 1887, page 160.

† Equal to 534 oz. 2 dwt. of metallic silver per ton.

The earliest official record is that of the late Government Geologist, Mr. C. S. Wilkinson, in $\frac{1877}{p.652}$, who stated that good sulphide ore was shown him, which had been partly worked, but the mine was then idle. A sample purporting to come from the lode was assayed ($\frac{4407}{96}$) for a yield of 14 per cent. of copper and 5 oz. 15 dwt. 9 grs. of silver per ton.

In August, 1898, the mine was again receiving attention, and a pumping plant was shortly afterwards erected to unwater the old shaft, which, according to Mr. J. Reed, Manager of the Apsley Copper Mine, is about 70 feet deep, and driven 80 feet on the course of the lode. A good bunch of ore is reported to have occurred about 8 feet wide under the old adit, but in the bottom of the shaft the lode was of no value. The same authority estimates that probably 1,000 tons of ore were put through the two furnaces erected at the mine.

Mr. H. Hooke, Inspector of Mines, who recently examined the workings, states (Pros. Papers, 98–3,250) that apparently payable ore is visible in the bottom levels.

Eureka Copper and Silver Mine, L., Condobolin Dn., situated near Condobolin ; opened in $\frac{1888}{p.79}$; idle in 1891.—No particulars available.

Eurow Copper Mine, L., Forbes Dn., about twenty miles east of Forbes, and nine miles N.E. of Eugowra.—This mine, held as an M.C.P., Portion 80, Parish Wise, County Ashburnham, is the original site of Sloan's discovery of copper in the locality about 1881. It is reported that 60 tons of ore were extracted in 1884, which yielded, at the Newcastle (Waratah) Smelting Works, 18 per cent. of copper. Recently it was again taken up and worked by a syndicate. It adjoins the Vychan Copper Mine, about 300 feet separating the workings. The Eurow was formerly known as Payten's Mine.

During the recent visit of the Writer, mining operations had ceased pending the result of treatment of a trial parcel of 20 tons of sulphides which, at the bottom of the present workings—89-foot level—is very massive and almost entirely iron pyrite. Apparently the result of the trial was not satisfactory, as the property was subsequently advertised for sale under a judgment for wages.

Water for domestic purposes is obtained from springs close to the mine, the Lachlan River being about eight miles distant.

Eyrie South Silver and Copper Mine, B., Rockley Dn. (*See* Wiseman's Creek Mine.)

Fidler's Station Copper Mine, L., Molong Dn., situated between Molong and the Kadumble Range ; opened about 1872.—No particulars available.

Fiery Creek, T. & A., Cooma Dn., twenty miles N.E. of Cooma, and six miles from Rose Valley Station, at foot of McAnally Mountain.—Copper carbonates occur in a deposit worked for gold.

Fisher's Copper Mine, P. & U., Nundle Dn., Dungowan Creek, about sixteen miles from Tamworth, in County Parry ; discovered in 1881.

In $\frac{1886}{p.136}$, the late Mr. C. S. Wilkinson reported that "lower down Dungowan Creek, on Mr. Fisher's land, some copper-bearing lodes have been opened in places for a length of about 8 chains, striking N. 10° W., and dipping westerly at 70°. These consist of several masses—of irregular size up to 10 feet long and 4 feet wide, and thinning out—of gossan and quartz, containing pyrites, native copper, red oxide, and carbonate of copper. They occur in greenish schists and jasperoid rocks. At the present low price of copper these small bunchy lodes could not be profitably worked."

Under date 19th July, 1898, Mr. Warden Jones writes that this mine in 1882, consisting of two mineral purchases of 40 and 50 acres, was leased to the Hon. P. G. King, M.L.C., and others for a period of fourteen years, but little work was done during the tenure of the lease, which expired in 1896. In that year Dr. Pratt secured the right to lease or purchase for a period of two years, which has just expired without labour being expended on the property.

The following assay was made in 1897 of a sample of green carbonate in ferruginous siliceous gangue ($\frac{\text{—}}{97}$):—Copper, 42·20 per cent.; silver, 2 oz. 19 dwt. 21 grs. per ton; gold, a trace (under 2 dwt.). Another sample of carbonate ore, selected by the Warden and forwarded with his letter of the date quoted, yielded ($\frac{\text{—}}{98}$) copper, 31·23 per cent.; gold, 2 dwt. 4 grs.; and silver, 1 oz. 8 dwt. 7 grs. per ton.

According to the *Australian Mining Standard*, 23rd March, 1899, Mr. Fisher had just received returns of 5 tons 13 cwt. 2 qrs. of copper ore from his lode, which he is opening on his own account, viz., 1 ton 3 cwt. 2 qrs. 1 lb. of copper; value, £83 14s. 4d. A further consignment of 6 tons yielded 1 ton 2 cwt. 25 lbs. of copper, which realized £107 13s. 3d.

Fitzroy Mine, L., Canowindra Dn., Parish Malongulli, County Bathurst, near the Belubula River, on Licking Hole Creek, a tributary of Liscombe Poole's Creek, about sixteen miles from Canowindra.—At this and the adjoining Belubula Mine some of the earliest mining for copper in the Colony was done. In 1845 work was progressing in the Belubula Mine, and the Fitzroy was the first opened, according to the late Mr. W. M. Rothery, of Cliefden Station, who also stated to the Writer that no payable ore was discovered in either.

Frogmore Copper Mine (formerly *Frogmoor*), S., Frogmore Dn, about seventeen miles north of Burrowa, in Parish Bála, County King; discovered in 1870 and taken up by J. Sheedy as a mineral lease.

In 1873 the English and Australian Smelting Company, Waratah, treated 4 tons 19 cwt. of ore from Frogmore for a yield of 9¼ per cent. of copper.

In the New South Wales Mining Statistics, $\frac{1876}{\text{p. } 90}$, this mine first receives official notice. Seventy tons of ore are reported to have been raised at this date from a lode averaging 3 ft. 6 in. in thickness at 75 feet from surface, and striking N.W. (dip, 1 in 6 westerly). The ore was estimated at 12 per cent. copper.

In 1880 work was suspended after about 50 tons of copper were produced.

In 1881 the mine was floated into the Frogmoor Copper-mining Company, having previously been worked by Messrs. Deer Bros. At the end of the half-year ending 31st December, about 50 tons of copper had been produced.

In $\frac{1882}{\text{p. } 24}$ 1,050 tons of ore raised yielded 118 tons of copper, 12 of which were produced by a wet process, which was not, however, in

Frogmore Copper Mine.

complete working order. The company was about erecting concentrating machinery to treat a large amount of lean ore at surface. Main (No. 1) shaft, 373 feet deep; No. 4 shaft, 360 feet.

In $\frac{1883}{p. 72}$ mining operations were confined to No. 4 shaft. At 288 feet in this shaft a new lode was struck, which junctioned with the main lode; the former, in one place, was reported to be 17 feet wide, the general average width being 6 feet. During the year about 1,275 tons of ore were raised and smelted at the mine for 127½ tons of copper, the results of the last half-year showing a fair profit.

The plant then consisted of winding and crushing machinery, two smelting and ore-refining furnaces, and chambers for manufacture of sulphuric acid. Thousands of tons of poor ores—the accumulation of years—were reported at grass, which it was proposed to treat by a wet process.

In 1884 the mine was worked, but owing to the low price of copper it was closed down in January, 1885. No official returns of the amount of copper produced is given, but in $\frac{1884}{p. 31}$ it is mentioned that 60 tons of ore were raised prior to closing, which yielded 6 tons 15 cwt. of copper.

In 1886 and '7 the mine remained idle.

In 1888 work was resumed, forty men being employed and 100 tons of ore raised. In $\frac{1889}{p. 86}$ the Mining Registrar stated that work had been recently resumed, and would be continued if the value of copper kept up. In $\frac{1890}{p. 90}$ smelting operations were continued for about three months, the balance of the year being occupied in sinking a new shaft and draining old workings.

In $\frac{1891}{p. 47}$ about 100 tons of ore only were raised. In this year Mr. W. Anderson reported, $\frac{1891}{p. 269}$, that a large amount of work had been done on this property. The lodes occurring in lenticular form in the strike of slate country near the junction of intrusive granite. "The lodes occur as isolated patches in a belt of altered schistose slates, which, near the lodes, were also impregnated with copper pyrites, so that, besides the true lodestuff, a large quantity of pyritous slate was raised and treated for the copper which it contained. There is a certain percentage of silver in the ore, which, together with the purity of the copper extracted, enhanced its value in London to nearly that of Chilian copper."

Mr. J. Stevenson, of Burrowa, informed the Writer that the last shipment of copper from the mine—in 1890—assayed in London 97·60 per cent. of copper, and 37 oz. 5 dwt. of silver, and 6 dwt. 12 grs. of gold per ton.

In 1898 the only work carried on was in an adjoining block to the east of the old mine; a shaft was down about 20 feet, from which 4 tons of ore had been sent to the Australian Smelting Works, Dapto.

Recently the Writer visited Frogmore Mine, the present aspect of which is best illustrated by the photographic view on the opposite page. Inspection was restricted to the surface features, as the workings are full of water. A considerable amount of "screenings" and "seconds" on the surface reveal the nature of the sulphides (which make their appearance at about 60 feet). Judging from these, concentration will be a necessity in any future operations. The surface indications are favourable for permanency in depth. Prospecting was being actively carried on in the immediate vicinity, particulars of which will be found under the head of Frogmore. (*See* also Bensusan's Mine, Frogmore.) The following statistical return has been prepared from the company's half-yearly reports.

Half-yearly Report ending—	Tons of Ore Raised.	Tons of Ore Smelted.	Tons of Copper Produced. tons	cwt.	qrs.	lb.	Average Yield per cent.	Deepest Shaft.	Deepest Level.	Remarks.
								feet.	feet.	
1st report—1 Jan., 1882	500?	500?	50	9	1	0	9·6	317	317	One furnace at work; ore raised from No. 1 and No. 4 shafts; underhand stope in No. 4 shaft, 50 feet long; quantity of "seconds" and "smalls" reserved for further treatment; sulphuric acid chamber being erected in connection with leaching process.
2nd " 31 July, 1882	550	520	55	2	3	0	10·6	354	354	Lode at bottom of No. 1 (deepest shaft) yielding about 6 tons of 10 per cent. ore per fathom, in addition to dreggy ore reserved for future treatment. No. 4 shaft yielding about 7 tons of 10 per cent. ore per fathom; about 3 tons of precipitate obtained from recently started leaching process.
3rd " 30 Jan., 1883	500	500	63	14	1	9	12·74	373	373	Sinking discontinued; ore chute in No. 4 60 feet; principal part of ore smelted from this shaft; lode about 4 feet wide; 10 tons of copper obtained from precipitates in wet process.
4th " 31 July, 1883	500	450	45	5	0	0	10·05	373	373	Operations retarded by drought; Handcock jig being erected; dam completed; two furnaces at work; north end of No. 4 shaft improving; large quantity of "seconds" and "smalls" raised in addition to ore smelted; little done with wet process.
5th " 29 Jan., 1884	800?	800	82	5	0	0	10·31	373	373	New lode discovered at 288-foot level in No. 4 shaft, 17 feet wide at its junction with the main lode; average width of new lode 6 feet, yielding 8 tons of 10 per cent. ore per fathom; two furnaces at work; jigging plant started.
6th " 22 July, 1884	535?	535	53	9	2	0	10·00	373	373	New lode not up to expectation, small, and producing about 4 tons of 10 per cent. ore per fathom; concentrating plant idle for four months owing to want of water.
7th " 17 Jan., 1885	... ?	460	48	0	0	0	10·43	373	373	Copper market low; operations unsatisfactory; concentration intermittent; one furnace only at work; treatment of carbonates by wet process abandoned; ore raised by tribute from branch vein in west wall of No. 4 shaft yielded 15 per cent. dressed.
	...	3,765	388	5	3	9	— 10·53 % extraction.		......	

It will be noted that the yield of the ore smelted during the company's operations averages 10·31 per cent. of copper, and, further, that as soon as the copper market became depressed operations ceased, and have practically never been renewed. The spasmodic attempt during the copper boom of 1888–9 was as brief as the boom itself. This mine certainly offers sufficient inducement for renewed effort.

A few hundred feet west of the main lode Mr. Bensusan opened another in Mr. J. Sheedy's property, and erected a reverberatory furnace. A good deal of work was done, but the results were not satisfactory. The two properties could, perhaps, be worked together in any new venture. Samples of the sulphides from both mines were selected from heaps at surface for assay, with the following results:—

$\frac{220}{99}$—Siliceous copper pyrites from Frogmore Mine:—

Copper	10 35 per cent.
Iron	13·54 ,,
Silica	54·60 ,,
Silver	1 oz. 14 dwt. 20 grs. per ton.
Gold	Nil.

$\frac{221}{99}$—Quartz with iron and copper pyrites from Bensusan's Lode:—

Copper	3·69 per cent.
Iron	16·32 ,,
Silica	58·00 ,,
Silver	13 dwt. 1 gr. per ton.
Gold	Nil.

McInnes and Cook are working a copper-vein on the north boundary of M.C.P. 51, Parish Alton, County King, belonging to the Frogmore Proprietary. A shaft has been sunk 50 feet on the vein, which traverses crushed porphyry and schist. Three tons of ore extracted down to water-level yielded 14½ per cent. of copper, and silver 6 oz., and gold 3½ dwt. per ton.

On the south boundary of the Frogmore property the same party are working a 5-acre lease under private agreement on Portion 74, Parish Bala, County King. Country crushed porphyry and schist, with copper carbonates in the laminæ for a distance of 17 feet in a crosscut; in fact, copper carbonate colourings are discernible through a wide belt of these rocks at Frogmore. From a more concentrated deposit in a new shaft about 6 tons of good ore have recently been treated at the Dapto Smelting Works for a yield of 17·6 per cent. of copper, and 5 dwts. 14 grs. of gold per ton.

Gilgunnia District, C., Gilgunnia Dn. (*See* May Day Mine).—Copper ore also occurs in small quantity about two miles N.E. from Gilgunnia, near the Peaks, and on the Gilgunnia-Nymagee road, about seven miles from Old Gilgunnia.

Gilmandyke Creek, B., Rockley Dn. Parish Rockley, County Georgiana.—In $\frac{1877}{p.200}$ Mr. C. S. Wilkinson, Government Geologist, recorded the occurrence of quartz veins carrying copper pyrites, traversing greenstone, on the Summerhill Estate, but expressed doubts as to the presence of payable quantities.

Girilambone Copper-mine, C., Nyngan Dn., Great Western Railway-line, 405 miles west of Sydney, Parish Gidalambone, County Cambelego (situated on Portions 2 and 3, originally taken up under Volunteer Land Orders). The actual date of discovery of this mine is in dispute; but there is no doubt that it was first opened in the beginning of 1880 by Messrs. Hartman, Campbell, and others, the two named being also connected with the discovery and opening of the Great Cobar Mine.

Mr. Hartman's statement, briefly, is that in 1875, whilst proceeding from the Bogan River to Cobar, he camped at some "gilgai," water-holes, close to Girilambone Hill, and, from his experience at Cobar, recognised the characteristic blue and green stainings of copper carbonates at the site of the present South Shaft. As the outcrop was small he did not set much value on it at the time, but contented himself with taking with him to Cobar a sample of the surface ore which is still in his possession.

In 1879, accompanied by his brother-in-law, Charles Campbell, and two others, he again visited Girilambone and marked out four 40-acre mineral conditional purchases, and proceeded shortly afterwards to mine the surface ore, which consisted largely of rich red oxide. His title was then disputed by Messrs. W. W. and T. L. Richardson, on whose run (No. 5 West Bogan) the mine was situated, the latter claiming a prior right by Volunteer Land Orders. According to Mr. Hartman, his partners not being sufficiently impressed with the importance of the deposit—as the red oxide was only from 3 to 12 inches thick in flat layers down to 10 feet—relinquished their claim to it rather than enter into litigation. Mr. T. L. Richardson states that his attention was first drawn to the outcrop in 1880 by a stockman on the run, who had been attracted by the colour of the rocks. The land was then secured as already stated. It seems unquestionable, notwithstanding the conflicting dates, that the site was known to the owners of the run prior to the advent of Hartman and party to begin mining, but the action of the latter practically led to the opening of the mine.

Girilambone, in the aboriginal language, signifies a "falling star" or meteorite.

The first official record of Girilambone Mine is that by Mr. L. H. G. Young, Geological Surveyor, who visited it in company with the Writer in $\frac{1880}{\text{p. 262}}$. "The copper deposit is situated on No. 5 West Bogan Block, near the north-west corner, and on the summit of a small hill long known as "Copper Hill."* The lode has a strike N. 18° W., and dips to the eastward at an angle of 56°. A small trench has been made across the lode, showing it, for a width of 18 feet, to be composed of veins of quartz, including between them bands of slate and occasional bunches of extremely rich red oxide of copper coated with green carbonate. The lode may be again seen 100 yards to the north of the trench, and copper indications also occur about 30 yards to the N.E. of the same place. The strike of the slates is N. 12° E."

In $\frac{1881}{\text{p. 21}}$, a company was formed and the mine opened, the lode so far as tested appearing from 6 to 25 feet wide. 650 tons of ore were raised during sinking and driving. Furnaces were in course of erection.

In $\frac{1882}{\text{p. 34}}$ the deepest level was 198 feet from surface; the lode at this point being 6 feet wide. 2,000 tons of ore were raised during the year, but only 10 tons of copper were produced. Mr. T. L. Richardson states that after the furnaces were erected the ore was found difficult to treat, and little was done in this line, the output being sent to the English and Australian Smelting Works at Waratah.

In $\frac{1883}{\text{p. 117}}$ 130 men and boys were employed until the end of April, when twenty-two only were retained sinking a new shaft. The main shaft reached a depth of 252 feet, the lode varying from 2 to 19 feet in width. 450 tons of ore raised during the year yielded 32 tons 4 cwt. 1 qr. of fine copper, valued at £1,655. Value of plant, £7,500. Population, about 500.

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* Mr. T. L. Richardson states that this is an error, the name not being known prior to the date mentioned.—J.E.C.

GIRILAMBONE COPPER MINE.

(Main Stope, No. 4 level.)

In 1884 prospecting by means of a new shaft was carried on. The Chief Inspector of Mines, Mr. W. H. J. Slee, reported $\frac{1884}{\text{p. } 120}$ that bunches of ore were struck at the following levels—86, 122, and 300 feet.

From 1885 to 1893 the mine was not worked.

In 1893 it was let on tribute, and ore extracted to the value of £957.

In 1894 two or more tributes were let, the output being 36½ tons of copper, valued at £1,180.

During 1895–6 the mine was again idle.

In October, 1896, the Girilambone Copper Mining Company, Limited, was formed, and active operations begun, 200 men being employed. The main shaft was deepened to 320 feet. 17,154 tons of ore were raised during 1897; estimated copper contents, 733 tons. Smelting and refining were commenced and 173 tons of copper produced, the quality of which may be judged from the following extract from the *Australian Mining Standard* of the 6th January, 1898:—"Mr. L. Dodds, Manager, Girilambone Copper Mining Company, Ltd., has received a telegram from London on the first 50 tons of copper sent from the mine. The report states that the assays showed 99·95 per cent. of copper, which is equal to the best English 'selected,' and that the malleability of the copper is very good."

Recently the Writer had the opportunity of examining the developments to date.

The country consists of slates and sandstones, with occasional hard bands of quartzite, the latter forming a few low hills in the neighbourhood which are conspicuous features above the general level. Girilambone Hill is of low elevation, with a bare outcrop of rocks, chiefly quartzitic. The copper ores occur as segregations and replacements in the country without the defined limits of ordinary fissure lodes. The matrix consists of silky, schistose, and fine sandy slates, with numerous quartz veins and inclusions. In an open cut—a relic of early operations—at Datson's shaft, the folding and contortion of the country is well defined by infiltration of copper salts—blue and green carbonates—along the lines of folding, imparting to the mass a wavy banded character.

The zone of surface oxidation extends just below the 200 feet level. The present oxidised supplies are being drawn from the 140 feet level in the south shaft. In this lode, isolated patches and nodules of red oxide of copper occur in the softer country, following the wavy folds of a hard quartzite band, locally known as the "ironstone lode."

The carbonate ores are seldom homogenous and solid, but principally earthy and pulverulent; even the apparently pure azurite particles contain little more than half the theoretic value in copper, whilst the malachite rarely approaches even this proportion.

Between the zone of complete oxidation and the unaltered sulphides at 220 feet, there is a gradual transition, the upper extensions of the sulphides being coated, and in places entirely converted into loose earthy melaconite—black oxide of copper—which unfortunately is difficult to save in concentration.

Serious difficulties at Girilambone are the close association of silica (quartz) with the copper ores, and the absence of solid iron sulphides. Wherever the copper ores occur most concentrated in either the oxidised or sulphide zones, quartz is most abundant; hence, owing to the nature of the ores, and the mode of their occurrence in the matrix, concentration by jigging results in a high percentage of silica being retained with the ore. The clayey material of the earthy ores, and the soft schistose matrix, is mostly removed during the operation. The first concentrates, which are used for fluxing the oxidised ores, contain about 53 per cent. of silica. Added to this, the silica in the local iron ore, also used for fluxing, amounts to 16 or 18 per cent.

Development.—The main shaft has now reached 544 feet, but for the last 120 or 130 feet it has passed out of the lode, which has dipped away from the shaft. The deepest working level is 300 feet, but another is being driven at 520 feet. Other working levels are the 200 and 140 feet. The south lode is connected with the main shaft by a cross-cut at 140 feet level, through which all the haulage is done. The south lode strikes about north-west whilst the main lode has an apparent east and west course.

In the fifth Half-yearly Report—28th February, 1899—Mr. W. Blakemore, Mine Manager, states that the main shaft, 544 feet deep, has been securely timbered and divided into compartments. Little work was done at the 360 feet level—insufficient to determine the value of the lode at this depth. At the 300 feet level, the west drive has been extended 70 feet on the course of the lode. Ore stoped, 25 feet wide, 200 feet level. A new stope opened in south-west drive, consisting of malleable copper, grey and carbonate ores. No work performed at the 140 feet level during the half-year, beyond completing the cross-cut to the south workings.

The sulphide supply in sight is sufficient for several years, and will be largely increased when the lode is cut in the 520 feet level from the main shaft.

A new tank of 6,000 cubic yards excavated; old tank cleaned out.

Treatment of the Ores.—The oxidised ores from the upper levels are roughly sorted at the surface by hand picking and screening, the richer portions going direct to the smelter's charging bins; poor lumps are discarded, and the balance sent to the ore-breaker for preparation for the jigs. The sulphides on the other hand go direct to the jigs.

The ores raised are divided into three classes, distinguished as "carbonates," which include the red oxide and carbonates from the south lode; "sulphides," which embrace all the sulphides from the 240 and 300 feet levels; and "oxides," from the transitional zone between the former.

The "carbonates," as mined, have an average assay value of 4·6 per cent., according to the half-yearly statement for June 30th, 1898, which is based on weekly average assays. About 40 per cent of this class of ore is sent direct to the smelters after breaking and picking, and averages 13 per cent. A small proportion is discarded, and the balance goes to the ore-breaker and jigs. The screenings of this class naturally form a considerable part of the whole, owing to its soft earthy nature. The richer portion, which goes direct to the charging bins, consists chiefly of isolated lumps of red oxide, coated with carbonate and associated with quartz.

The "sulphides" and "oxides" go direct to the concentrating plant, which consists of a Gates Rock-breaker, Cornish and Krom Rolls, and Handcock's and May Bro.'s Jigs. Wire-wove ¼-inch mesh trommel screens are used in connection with the rolls.

Each class of ore is treated separately. The crushed material from the breaker is divided between the Cornish and Krom Rolls, the coarser material from the former passing to a *Handcock's Jig (of obsolete pattern), and the finer from the Krom to May Bro.'s Jig.

The first concentrates go to the charging bins, the seconds are stacked for further possible treatment, the balance passing to the waste heap.

From the appended detailed statement for the half-year above quoted, it will be noted that under existing conditions it has only been possible to

*Since replaced by one of Handcock's latest and most complete jigs, having a capacity of 100 tons per day.

GIRILAMBONE COPPER MINE.
(Main Drive, No. 1 level.)

obtain in the picked ore and the workable concentrates about 66 per cent. of the estimated contents of the out-put. This percentage is still further reduced by loss in smelting. The actual extraction approximates to about 50 per cent. of the estimated contents of the ore raised. The causes of this low extraction will receive attention under the heads of Concentration and Smelting.

(a) Concentration.—The earthy carbonates and oxides (chiefly screenings), are concentrated to an estimated average assay value of 10·9 per cent. of copper, but a glance at the "seconds" reveals a considerable loss, chiefly in blue carbonate. Attention was given by the Writer to the possibility of mechanically separating these particles after careful sizing, but the difference in specific gravity between the carbonate and the waste is so slight (0·73) as to render mechanical separation impossible. The green carbonate particles, which are also conspicuous on the "second concentrates" heap, need only a glance to establish the fact that their copper contents are more apparent than real. Mostly, the green particles are quartz stained by malachite, the average specific gravity of which is 2·74, whilst that of the slate waste is 2·72. An assay of apparently pure azurite (blue carbonate) yielded only 31 per cent. of copper as against 53·2 per cent. in the pure mineral. In view of these facts, it does not appear that the present loss can be averted in mechanical concentration. The possibility of a leaching process for poor oxidised ores is considered on pages 26 and 27.

The most important question in concentration, however, refers solely to the sulphides, the estimated copper contents of which, under present manipulation, are increased from 3·1 to 6·5 per cent., and the estimated extraction of which amounts to about 50 per cent.

The estimated percentage of copper in the seconds and tailings in the Half-yearly Report, June, 1898, is 5·8 (based on average assays), from all classes of ore. It has been demonstrated that there is little hope of better mechanical recovery in the case of the carbonates and oxides; the question, therefore, is whether cleaner concentration is possible in the case of the sulphides. In the first place, the copper and iron sulphides mainly occur sparingly distributed through a greenish schistose slate, and it is specially noticeable that where the sulphides occur most concentrated that quartz is abundant.

To crush direct to a fineness sufficient to free all the scattered sulphide crystals would, probably, in the absence of an abundant water supply, increase instead of reduce the present loss, owing to the great tendency of the matrix to slime. From a study of the nature of the ore, and the natural difficulties of concentration, a few possible improvements in manipulation suggest themselves; the most important being preliminary sorting of the ore on the surface in place of crushing everything as it comes from the working faces. It is unquestionable that a good deal of absolute waste was going to the jigs at the time of inspection, and adversely affecting the results proportionately with the quantity added. If the sulphide ore was screened, and the larger material broken and sorted by cheap boy or elderly labour, a good proportion of waste could be at once discarded, and possibly a percentage of smelting ore selected, the balance and the screenings going thence to the concentrating machinery.

In view of the tendency to slime, and the limited water supply, the first crushing should not pass a finer mesh than at present. If, however, the seconds offer sufficient inducement, a further and finer crushing might follow with further jigging, though far better results would be obtained by use of buddles or vanners. Both the latter are in extensive use in Montana, United

States, where fine crushing and concentration are carried out on a large scale. The Anaconda Company are understood to have adopted buddles wholly for the fines.

According to Dr. Peters, junior,* even with the most approved apparatus, and careful running, it is usually impracticable to concentrate sulphide ores of copper with a loss of much less than 25 per cent. With copper glance and bornite, Dr. Peters's experience has been a loss of 33 per cent. in concentration.

In large low-grade siliceous deposits, it therefore becomes a question for consideration, after careful testing, whether it would not be more advantageous to waste a proportion of the ore in the "seconds" than attempt to save it at an increased cost for further operations.

The following copy of one of the half-yearly returns of the Company's operations will reveal the nature and proportions of the different grades of ore raised, and the results of dressing and concentrating operations:—

The Girilambone Copper-mining Company (No-Liability). Half-year ending 30th June, 1898.

	Ore Account.				*Copper Contents.*	
	tons.		per cent.		tons cwt.	tons cwt.
Ore raised and jigged—						
Carbonates	2,579	@	4·6	=	118 12	
Sulphides	3,263	@	3·1	=	101 3	283 12
Oxides	953	@	6·7	=	63 17	
	6,795					
Screened Ore—						
Carbonates	1,109	@	13·0	=	144 3	145 7
Sulphides	44	@	2·8	=	1 4	
	7,948					428 19
Jigged Ore—			*Producing.*			
Carbonates, No. 1 ...	464	@	10·9	=	50 11	
Sulphides, No. 1......	706	@	6·5	=	45 17	139 10
Oxides, No. 1	273	@	15·8	=	43 2	
„ No. 2	859	@	3·5	=	30 0	
„ No. 3	64	@	4·0	=	2 11	101 8
Tailings..................	2,994	@	2·3	=	68 17	
Slimes and waste ...	1,435				(say)	42 14
						283 12
Screened Ore—						
Carbons..................	1,109	@	13·0	=	144 3	145 7
Sulphides	44	@	1·4	=	1 4	
						428 19

Smelting.—Smelting operations at Girilambone are greatly hampered by deficiency of sulphur and iron and excess of silica.

Owing to the want of sulphides in more concentrated form to charge with the red oxides and carbonates from the south lode, reduction is too rapid, the first regulus occasionally containing over 70 per cent. of copper. In roasting such rich matte, black slags frequently result, containing prills of metallic copper equalling 8 to 12 per cent. Unfortunately these rich slags, under present conditions, cannot be recharged into the furnaces owing to

* Modern Copper Smelting, 7th Edition, 1895, p. 611.

Girilambone Copper Mine.
(150-ft. level. South.)

their high silica contents, which would but aggravate the evil when the fresh charge is already too siliceous; hence a considerable amount of copper at the present time is unreclaimable, and the quantity is increasing.

The following figures represent the average assay results of silica and iron obtained by the Company's Assayer and Analyst—Mr. H. Elphinstone—from the different classes of ore and the flux forming the furnace charges:—

	Silica per cent.	Iron per cent.	
Carbonates and Red Oxide	45·2	17·8	Average of 19 weekly assays.
Sulphides	46·2	24·4	" 24 "
Oxides and Sulphides	44·4	18·7	" 10 "
Ironstone flux	16·2	49·	Average assay.

The charge is usually composed of 18 to 20 cwt. of carbonates and oxides, 10 cwt. of sulphide concentrates, and 12 cwt. of ironstone flux; but the latter varies according to percentage of silica in the charge. Two barrow-loads of charcoal are added with each fresh charge.

Owing to the want of sulphur, only about two charges per shift are possible—some, indeed, occupy seven hours in reducing. The regulus, or matte, usually from 60 to 70 per cent. grade, is tapped after the fourth charge. In the roasting furnace it is reduced to pimple copper, and then passes to the refinery, which is put in operation monthly.

The output of copper for the eleven months ending 31st August, 1898, during which the furnaces had been running, amounted to 389 tons, equal to a monthly average of 35·3 tons; the last six months averaging 30·6 tons, against 41 tons for the first five months.

The quality of the copper produced is highly creditable, and testifies to the absence of injurious metallic associates in the ores. Its assay tenor reaches 99·95 per cent., and places it at top market value.

Furnaces.—The deficiency in sulphur and iron, and the highly siliceous nature of the ores at Girilambone, render reverberatory furnaces most suitable. The smelting plant consists of five reducing and one refining furnace, erected by G. Maliphant, an employee of the Company. The dimensions of the former are 21 ft. x 15 ft. and 20 ft. by 15 ft. The previous furnaces were built of Waratah firebrick, of which the crowns of those now in use are constructed. Locally manufactured bricks, however, are now entirely replacing the former and are found to answer well, having a life of about eight weeks in the bridges and throats of the furnaces.

In the section devoted to refractory materials and fireclays, analyses of both Waratah and Girilambone fireclay will be found. The Girilambone is essentially a silica brick—being composed of about 95 per cent. of pure quartz gravel and sand, the balance being an aluminous clay resulting from the degradation of the soft schistose slates of the vicinity. The material is obtained about 1 mile from the mine. When burnt the bricks resemble ordinary "red brick" in appearance.

Furnace mortar is prepared from the finer clay, ground firebrick, and slimes. Fettling is abundant in the numerous quartz reefs of the locality. Ironstone flux is procured about six miles from the mine. Limestone, occasionally used in freeing the furnaces, is brought by rail from some distance.

Wood is used for firing, the supply being conveyed by horse teams.

Water Supply.—Water supply is a serious consideration at Girilambone, owing to the necessity for concentration. Fortunately the mine workings furnish from 40,000 to 45,000 gallons per week. There are no natural channels worthy of the name in the vicinity, so that conservation is by open tanks. During the recent drought water for steam purposes had to be carted.

The Company has, however, now increased the storage capacity of the mine tanks. The mine water is used for concentration. From the jigs it passes to temporary filter dams, from which it is pumped back and constantly reused.

The smelting operations of the company are clearly defined in the following copy of the Half-yearly Report ending 30th June, 1898:—

Ore smelted.

	Tons.		Per cent.		Tons	cwt.	Tons	cwt.	qr.	lb.
Concentrates—										
No. 1 Carbonates ...	464	@	10·9	=	50	11				
No. 1 Sulphides	706	@	6·5	=	45	17				
No. 1 Oxides	273	@	15·8	=	43	2				
Old stock—										
No. 1 Carbonates ...	107	@	10·1	=	10	14				
							150	4	0	0

Screened ore.

Carbonates	1,109	@	13·0	=	144	3				
Sulphides	44	@	2·8	=	1	4				
							145	7	0	0
							295	11	0	0

Copper won.

		Tons.	cwt.	Tons	cwt.	qr.	lb.				
Dispatched				153	4	2	1				
Balance, 1st July	=	64	0								
Less balance, 31st Dec.	=	10	10								
				53	10	0	0				
								206	14	2	1

Summary.—The size and permanence of the Girilambone Lodes are well assured; the grade, however, is low when the nature of the matrix and the mode of occurrence are considered. In actual yield it compares very favourably with mines affording profitable returns, but the absence of solid sulphides prevents smelting concentration by blast or pyritic methods. Future success appears to depend upon a larger water supply and more efficient mechanical concentration; for the latter, buddles and vanners are requisite. The concentrating plant should be allowed a campaign ahead of smelting operations to ensure an adequate and continuous supply for the furnaces.

Since the above note was written the new Mine Manager, Mr. W. Blakemore, has erected a small brick furnace, worked by fan-blast, for treating slags, and for experimenting with the ore. To quote the 5th Half-yearly Report of the company, 28th February 1899,—"61 tons of slag—presumably the black slags accumulated at the reverberatory furnaces—have been put through the furnace, which smelted freely, without material injury to the furnace, although the bricks are very inferior; but as no fluxing ore was available at the time, the slags retain the bulk of their copper contents." [This furnace has since been run by the Metallurgist—Mr. Crichton—on various mixtures of ores and slags with reported good results.—J.E.C.]

"With the addition of the necessary sulphide ore, the large accumulation of slags at the smelting works, together with the second and third concentrates from the jigger after rejigging, can be profitably smelted at a considerable reduction on the previous cost of smelting."

The Company has since decided to erect a large furnace—a modification of the "Orford" furnace, and is very confident of success.

GIRILAMBONE COPPER SMELTING WORKS.
(Reverberatory Furnace, showing sand moulds filled with matte.)

GIRILAMBONE COPPER REFINERY.

(Ladling refined copper into ingot moulds.)

Output for the half-year ending 31st December, 1898:—Ore raised, 6,487 tons, averaging 3·85 per cent., equal to 249 tons 14 cwt. 3 qrs. 26 lb. of fine copper; consisting of:—

	Sulphides	4,252
	Carbonates	2,153
	Oxides	82
		6,487
Ore jigged—	Sulphides	4,252
	Carbonates	871
Yielding respectively—	Sulphide concentrates	958
	Carbonates	442
		1,400 tons,

of an average value of 8·76 per cent.

Together with 1,281 tons of unjigged 10 per cent. carbonates, making a total of 2,681 tons sent to the furnaces for smelting—2,371 tons smelted yielded 215 tons of fine copper.

Girilambone District, C., Nyngan Dn. (*see* Girilambone Copper Mine).—About three-quarters of a mile northerly from Girilambone Mine, Christensen and party took up a mineral conditional purchase of 40 acres, embracing a gossan outcrop, and sank 90 feet in it. A little carbonate of copper was obtained from the bottom of the shaft.

About three miles north-westerly, Hartman and party opened another gossan outcrop, under aid from the Prospecting Vote, to a depth of 150 feet, and drove upon it for 200 feet. In the drive carbonate of copper veins were cut, but were not payable.

Glanmire, B., Bathurst Dn.—At Green Swamp, about three and a half miles from Glanmire, copper mining was carried on about twenty years ago, the ore being sent to Lithgow Smelting Works. According to Mr. Reed, Manager of Apsley Mine, a shaft has been sunk 70 feet, crosscut 20 feet, and a winze from the crosscut sunk 50 feet. The lode is about 1 foot thick, carrying good sulphide ore.

Glen Innes District, P. & U., Glen Innes Dn.—Copper ore is reported eighteen miles from Armidale, near the Grafton Road.

Gloucester District, H. & M., Copeland Dn.—A sample of copper ore from Brown's Lease ($\frac{4320}{98}$) yielded 11·18 per cent. of copper; another from Hooke's Reef ($\frac{504}{96}$) yielded 11 per cent. of copper and 10 oz. of silver per ton.

Goimbla.—Copper is reported on Goimbla Station, between it and Bumbery, on the Molong–Parkes Railway Line.

Good Hope Copper and Lead Mine, S., Yass Dn., situated on the north bank of the Yass River, about seventeen miles from Yass.—This was probably one of the earliest-opened copper mines in the Colony. In a despatch from Governor Sir Charles Fitzroy to the Right Honorable Earl Grey, dated 1st March, 1849, mention is made of copper mines in operation in the neighbourhood of Yass and at Molong (Copper Hill).

The ore consists of copper carbonates, with sulphides of copper and lead sparingly distributed through a matrix of fluorspar. A smelting furnace was erected in 1870 at the Woolgarlo Mine, on the opposite side of the river, but, being placed low-down on the banks of the stream, it was washed away shortly afterwards during a high flood.

Mr. Argyle McCullum, under date August 7th, 1898, has kindly supplied the following particulars:—The outcrop is large, and can be traced for nearly a quarter of a mile. Several rich patches of ore have been found, but the main body of the lode is of low grade, the ore being too disseminated through the large mass of matrix. About forty years ago the Scottish-Australian Mining Company expended a considerable sum prospecting the Good Hope lode, and it was reported that at a depth of 180 feet a lode of sulphide ore was cut, about three-quarters of a mile from the main outcrop.

About 1896, 100 tons of ore were sent away from the mine, but apparently the return was not encouraging, for work was abandoned.

At the English and Australian Smelting Works, near Newcastle, a parcel of 37 tons 8 cwt. of ore from Good Hope was treated, for a yield of 15 per cent.

The nature of the matrix—fluorspar—renders the lode-stuff of value as a flux if central smelting-works should eventually be established in the district.

Goodrich Copper Mine, T. & T., Ironbarks Dn. (formerly known as Buckenbah and the Gordon Mines). The Goodrich Mine is situated about four and a half miles from the village of Yeoval. The ore occurs in quartz veins in granite, and consists of chalcopyrites, magnetite, and a little molybdenite and gold and silver. The mine has been worked as an open quarry to a depth of 120 feet by a width of about 70 feet.

According to Mr. Gibson, of Yeoval, the lode was discovered about 1868, and was shortly afterwards taken up by Messrs. Wynne, Gibson, and party, who worked it as a gold mine for twelve or fourteen months, extracting in that period 800 tons of stone which yielded by battery treatment 1,504 oz. of gold, of the value of 58s. 9d. per ounce only, on account of the large admixture of silver.

At surface the deposit presented the appearance of a small cone of brown iron ore in granite. From this point the gold-bearing quartz veins dipped away in annular form, so that as the excavation proceeded the central cone was left standing. The party worked the auriferous ring about 16 feet wide to a depth of 28 feet, when copper pyrites were encountered, which rendered their battery treatment ineffective and influenced them to dispose of the property to a syndicate, who erected furnaces under the direction of Mr. Lewis Lloyd, to treat the copper ore. The syndicate, in blasting away the central cone, are reported to have obtained a good bunch of workable ore.

Mr. Gibson states that smelting was continued for about seven years. The furnaces—two reducing and one refining—were erected on the Little River, about three-quarters of a mile from the mine. The ore was cobbed and picked by hand, the fines being jigged. The refined copper is reported to have realised a high price, because, as subsequent assays proved, of the quantity of gold concentrated in it—equal to 3 oz. 17 dwt. 10 gr. per ton by assay. It is, however, probable, judging from the experience of Cobar, that the quality of the copper alone affected the sales.

After Mr. Lloyd's supervision terminated, mining was carried on for a further period of two years under Mr. Gibson's management, who states that the output averaged about 8½ tons of copper and 130 oz. of gold per month. Later the mine was purchased by Mr. J. Veitch, who worked it for gold only, but afterwards attempted, unsuccessfully, to smelt the cupriferous concentrates and tailings.

The quarry-like opening during the above operations assumed its present dimensions—about 75 feet by 60 feet by 150 feet, though the centre was not removed lower than 70 feet.

In $\frac{1886}{\text{p. 107}}$ Mr. Slee, Chief Inspector of Mines, reported that the monthly crushings under Mr. Veitch's management amounted to about 150 tons, yielding from 3 to 7 dwt. of gold per ton. The crushing plant consisted of a 20-head stamper battery, with grinders and concentrators constructed by the owner; a tramway of about three-quarters of a mile in length connected the mine and crushing machinery. After extraction of the free gold by battery treatment, the copper ore was roughly concentrated, over 1,000 tons of the latter being stacked at the date of Mr. Slee's visit, which the owner estimated by assay to contain 9 per cent. of copper, and 10 dwt. of gold, and 2 oz. of silver per ton.

After a fatal accident to a miner the open quarry workings were abandoned, and work ceased so far as winning ore is concerned. Subsequently a syndicate secured the property, on a purchasing option, and sank a shaft 145 feet in the country about 50 feet from the side of the quarry, and then abandoned operations before anything definite had been accomplished. Continuing this shaft well below the old workings into solid ground, and cross-cutting to the ore bodies, are the only practical ways of further development.

A large amount of lean ore is at grass, but the presence of copper precludes advantage being taken of cheap extraction of the gold by cyanidation. At the bottom, 4 per cent. concentrating ore is reported to exist. Pillars of ore have been left in the workings, and veins—hard and firmly attached to the country—are yet to be seen in the sides of the open quarry, dipping flatly away from the opening.

The mine is now again held, and recently the workings were unwatered, but developmental work has not yet begun.

One mile south of Goodrich Mine, the Buckenbar Copper-mining Syndicate sank 120 feet in a copper lode, the ore being disposed of to the Goodrich smelters, but the quantity was not large.

At Dilga Creek, six miles south of Goodrich, poor copper ore occurs, much mixed with other sulphides. (For other occurrences in the neighbourhood, *see* Tinby Hill.)

Gordon Mine.—See Goodrich.

Goulburn District, S., Goulburn Dn. (*see* Currowong and Mummell Copper Mines—). Copper ore is reported from Baw Baw, four miles from Goulburn, and at Lockyersleigh, where a copper lode of low grade was opened by shaft prior to 1863, but was not workable.

Great American Barber Copper and Gold Mine, N.E., Fairfield Dn.—G.L. 72 (D. Mickle and party's), situated near the summit of Mt. Carrington, Drake (which see). At 90-feet level, a lode varying from 1 foot to 3 feet in thickness, composed chiefly of copper carbonates, is being worked by the above party. 15 tons 1 cwt. of the ore treated at the Smelting Company of Australia's Works, Dapto, yielded 3 tons 18 cwt. of copper, equal to 24 per cent.

Great Barrier Copper and Silver Mine, A., Broken Hill Dn.—Blue and green carbonate ore was exhibited from this lode at the Melbourne Centennial Exhibition of 1888. The assay value was stated to be 29 per cent. of copper and 29 oz. 8 dwt. of silver per ton.

Great Central Copper Mine, C., Mt. Hope Dn., Parish Mount Hope, County Blaxland.—This mine was first opened about 1878, under the name of "McDowall's," after the discoverer. South Mount Hope, originally known as "Brown's," and afterwards as the Comet Mine, is now also included in the Great Central property.

The first official record is that by Mr. L. H. G. Young, Geological Surveyor, who visited the site, accompanied by the Writer, in $\frac{1880}{\text{pp. 260, 261}}$. Writing of South Mount Hope (Brown's), Mr. Young states:—"Here copper ore has been found in five or six places, but in my opinion the presence of a well-defined lode has not been established. The veins appear to run in a north and south direction, and are composed of quartz, earthy carbonates, red oxide, and a little grey and yellow sulphides; the rock adjoining the vein is a breccia of the porphyry of which the hill is composed."

Of McDowall's (Great Central) Mine, Mr. Young wrote:—The mineral deposit on this lease consists of a large mass of porphyry breccia, the pieces of porphyry being cemented together by oxide of iron containing a little copper; thus an assay of some of the cementing matter has been made by Mr. W. Dixon, F.C.S., and gave 4·32 per cent. of copper. Two shafts have been sunk, one—I was told—to a depth of 70 feet; but as this was half full of water at the time of my visit, I cannot tell what light it has thrown on the value of the property. Amongst the materials excavated I noticed some earthy carbonates and a little rich red oxide of copper. For a distance of 50 yards round the main shaft the rock is literally seamed with veins of red oxide of iron, varying in thickness from a film to 2 inches."

The Central and Comet workings are situated on the north and south slopes of the Central Hill—a mass of porphyry of some elevation. A distance of nearly half a mile separates the extreme north and south workings. The principal outcrop occurs at the south end, where the Great Central Company's operations have been carried on since the formation of the company. Here the porphyry, for a width of about 300 feet, is stained with copper carbonates, and seamed with thin veins of ferruginous oxide of copper. Four shafts have been sunk very close together on a band of lode-stuff on the east side of the spur, and numerous shallow trenches and potholes have been sunk on chutes of ore between the eastern and western workings, but no crosscut has been extended across the intervening formation. The shafts also are very rough, and inclined at all angles making haulage difficult.

The greatest depth attained is only about 240 feet. At this level sulphides, take the place of the oxidised ores. A drive at this depth just started—June, 1899—has already revealed an improved grade of yellow ore below the hauling shaft. A main shaft, with a proper system of levels and crosscuts, is badly needed. Judging from existing conditions, robbing the rich chutes, without regard to future developments, appears to have been the method of winning.

The matrix of the oxidised ores is decomposed porphyry, and consequently is soft and earthy, requiring a plentiful water supply for efficient concentration of the leaner grades, which, unfortunately for present operations, is not available. One small tank, and a mine supply equal to about 1,000 gallons per twenty-four hours, constitute the total provision. The surface configurations of the locality are eminently suitable for water conservation. An attempt was being made at the time of the Writer's recent inspection to turn the mine water to account in concentrating the leaner ores; but a glance at the jigs in operation, with such an inadequate supply, revealed a sludge, from which clean, or even approximately clean, work was an impossibility, in view of the constant reuse of the water. The jigs in use are modifications of the Handcock Jig.

Following the strike of the lode northwards, a belt of hard felsitic rock (elvan) crosses the ridge obliquely to the north-west; hereabouts the lode has not been traced by surface prospecting. Over the ridge, however, defined ore channels are encountered, which have been followed some distance south in the Comet workings. The main shaft of the Comet has been sunk 242 feet, and driven south as stated. Parallel ore veins occur here for a width equalling that of the Central workings. To the north from the shaft the country falls into a low saddle between the Central and a similar hill a short distance north. In this saddle is situated Brown's original discovery, known as South Mount Hope, an eastern lode distinct from that in the Comet.

On the east side of Central Hill, south of Brown's lode, two parallel lodes, one possessing a well-defined outcrop of ferruginous quartz, in which copper ore is visible, and gold, by assay, to the extent of 4 dwts. per ton. It has been opened in one place to a depth of about 50 feet, and the other lode—to the west—to 30 feet. It is reported that ore from these occurrences was sent to the smelters. They are worthy more systematic testing than they have yet received; indeed, the whole cupriferous belt embraced by the Great Central property offers considerable inducement for thorough and systematic proving, which should precede any present large outlay for improved plant. The latter could then be laid down on lines commensurate with the developments. Under any circumstances the water-supply could be largely increased with advantage to the proprietary. The necessary concentration at the present time is almost an impossibility. The oxidised ores are picked, the firsts going to the smelters, the balance to the breakers and jigs; the sulphides all pass through the latter. The former are concentrated to about 14 per cent., and the latter to 12 per cent., according to the present tributors. Ironstone flux is obtained from the mine, and fire-clay from the New Mount Hope deposit. The smelting plant consists of three reverberatory furnaces—two roasting and one refining.

RETURNS of the yearly output and progress of the Great Central Copper Mine, compiled from the Annual Reports of the Department of Mines.

Year.	Ore Raised.	Copper Produced.	Value.	Deepest Shaft.	Deepest Level.	Width of Lode.	No. of Furnaces.	Value of Plant.	Men Employed.	Remarks.
	tons.	tons.	£	ft.	ft.			£		
1881	..	..	..	..	..	..	..	..	..	
1882	..	..	..	..	..	..	..	..	..	
1883	1,139	187	8,700	120	120	3 in. to 11 ft.	..	2,600	102	Total ore raised since starting, 1,551 tons.
1884	2,221	336	14,784	206	150	1 ft. to 13 ft.	..	4,000	150	
1885 1886	..	..	..	..	..	..	..	..	..	Work suspended owing to low price of copper.
1887	..	..	..	..	..	..	..	..	..	
1888	..	142	..	..	..	..	..	..	130	Working eleven months.
1889	2,000	394	15,740	..	..	..	..	..	90	
1890	1,855	228	..	242	192	..	..	..	70	1,667 tons smelted.
1891	..	..	..	..	..	..	..	..	..	Mine closed.
1892	..	..	..	..	..	..	..	..	..	"
1893	..	..	..	..	..	..	..	..	..	"
1894	..	..	..	..	..	..	..	..	..	Ore to the value of £4,000 raised.
1895	900	134	5,093	242	192	..	..	..	..	
1896	454	55	2,195	..	..	..	..	..	..	Six months' work only.
1897	1,200	..	..	..	..	..	..	..	50	Mine let on tribute. Ore raised valued at £4,500. Engaged repairing plant, etc.
1898	1,100	110	5,800	..	..	..	..	..	..	

Mr. J. Doust, 60, King-street, Sydney, Managing Trustee for the present owners of the mine, states that the total output of the mine, according to the mine books in his possession, amounts to 2,170 tons of refined copper, of an assay value of from 99·15 to 99·65 per cent. The refined metal is free from deleterious impurities.

Great Cobar Copper Mine, C., Cobar Dn., Parish Cobar, County Robinson, 110 miles south of Bourke, on the Darling River, 80 miles west of Nyngan, on the Bogan River, and 459 miles west by rail from Sydney. The Cobar Company's property consists of 1,100 acres of freehold, on a portion of which the town of Cobar is built.

Historical.—Cobar (or Copar) in the aboriginal signifies "raddle" (earthy iron oxide), and from the outcrop of the copper lode the aboriginals formerly obtained it for decorative purposes. In process of time a small circular excavation resulted from scooping out the soft ochreous material, forming a catchment for water and serving as a "native well."

In 1869, two Danes—Thomas Hartman and Charles Campbell—engaged boring for water in the district, camped at the "native well," and were attracted by the rusty sediment at the bottom, and the blue and green stains on the sides, and for a limited extent around it. Neither were, at that time, acquainted with copper ores. The story of the facts leading to the discovery of the real nature of the colour which arrested their attention, is in dispute. Briefly, the account of the surviving discoverer—Hartman—is that, on raking the ashes of the camp fire made alongside the well, he discovered beads of metallic copper, which he took direct to Bourke and there displayed. The conflicting story is that Hartman and Campbell, taking with them specimens of the coloured rock, proceeded on their journey until they fell in with a Cornish woman—Mrs. Kruge—the wife of a countryman, who at once recognised the true nature of the colouring. On ascertaining its value, Hartman and Campbell returned to Cobar, and subsequently, (on the 6th of October, 1870, according to Mr. Russell Barton,) at Fort Bourke, secured the land as a mineral conditional purchase of 40 acres in conjunction with the late Joseph Becker of that place. The latter, in May and June, 1871, also secured 40-acre blocks adjoining the Cobar on the north and south. In January, 1876, the South Cobar Mining Company was amalgamated with the Cobar under the present title of "Great Cobar."

From a recent inspection of the portion of the outcrop and the native well, still remaining intact, it seems improbable that native copper occurred directly on the surface, in which form alone could it have been melted into the beads reported by Hartman, for there is no question that the small camp fire could not have reduced the metal from its ores. Circumstantial evidence therefore, supports the rival story; but none the less the credit of discovery rests with Hartman and Campbell, whose intelligent curiosity prompted transport of specimens which had drawn their attention. Lack of this valuable trait has frequently led to sources of wealth being undeveloped for years, until the advent of one of greater inquisitiveness or knowledge. In contrast to the action of the Cobar discoverers, the Writer recalls the statement of a shepherd he met at Mount Hope Copper Mine shortly after its discovery. Located within a few hundred yards of the outcrop on Mount Hope, he had often remarked the blue and green colours as he followed his flock over it, but intelligent prompting was wanting in this case.

Prior to the discovery of payable tin ore in New England in 1872, the gold miners were greatly hampered by the heavy black sand (tin oxide) in their sluices, which caused endless trouble in separating the gold. Instances might be multiplied, but sufficient has been written to illustrate the value of intelligent curiosity in regard to Natures' mineral treasures, many of which—unlike copper—she dresses in very unattractive garb, but which, nevertheless, possess distinctive characteristics, either of form or gravity, which compel attention. Notice might here be drawn to the ready means of identification available to even the poorest which the Government of the Colony has wisely

GREAT COBAR COPPER MINE.

(74-fathom level.)

established—a free laboratory and experts to determine the nature and value of any substance discovered, without cost to inquirers, having been provided in connection with the Department of Mines and Agriculture.

Shortly after operations were started at Cobar by Hartman and Campbell, Mr. Russell Barton—since well known in connection with copper-mining in the Colony—passing the locality, visited the mine, and, being greatly impressed with its possibilities from the insight he had gained in South Australian Copper Mining, purchased an interest. Rich ores were extracted from near the surface and dispatched by team to the Darling River at Bourke, and thence by river steamer to Port Adelaide Smelting Works, South Australia Some 3,000 tons are reported to have been thus disposed of at a profit.

In January, 1876, the Cobar and Southern Cobar Copper Mining Companies (Limited) were amalgamated under the title of the Great Cobar Copper Mining Company (Limited) of 80,000 shares of £1 each. (For particulars of the Southern Cobar Mine, *see* description under that title.)

Extraordinary difficulties faced the new company. A mine situated 459 miles (railway measurement) from the sea-board, in an arid tract, destitute of natural drainage channels (the nearest being the Bogan River, 80 miles distant), subject to drought, with an unevenly distributed annual rainfall, averaging only 17·21 inches according to the Government Astronomer, and a greedily absorbent sandy soil.

The nearest railway at the beginning of operations was Blayney (opened in November, 1876), distant by the present railway-line 287 miles from Cobar. In April, 1877, the Orange extension was opened, which reduced the distance to 267 miles. The ordinary roadway, however, probably covers a much greater distance between the points mentioned.

That the company has been enabled under such handicaps to pay dividends, amounting to more than two and a half times the total capital, is eloquent testimony to the richness of the mine. In 1889 the company had to suspend operations owing to the extremely low price of copper and excessive cost of transport. The failure of the Société des Metaux, and the collapse of the "copper boom" it had originated, were the direct causes of the Company's suspension, as an agreement had been entered into for a term of three years with the Société for the purchase of the entire output from the Cobar Mine at £60 per ton on board ship at Sydney. The Company intended resuming operations on completion of the branch railway line from Nyngan to Cobar.* In 1893, however, the mine was let on tribute to the present Great Cobar Mining Syndicate, which began operations when the average value of copper was but £39 per ton, and successfully introduced the cheaper and more rapid blast-furnace method of reduction, which has revolutionised the copper industry at Cobar. A previous attempt with blast-furnaces (not water-jacketed) was made in 1885, when three were erected at a cost of £5,000. After a short campaign with charcoal fuel they were discarded, though the Mine Manager, Mr. J. Dunstan, regarded some of the experiments as satisfactory. 325 tons of ore were smelted in these furnaces. The cost of charcoal alone would have rendered profitable working impossible at this date. Rapid and certain railway transit has effected no less complete a revolution in cost of production. Prior to the advent of the railway, the Company was dependent on teamsters for freightage to and from the mine, and the latter again were entirely dependent upon the seasons. During a drought in 1882–3, it was found almost impossible to maintain the necessary

* Railway to Cobar opened in 1891.

supply of firewood, whilst the stock of copper in the sheds at the mine increased to over 1,200 tons, owing to the impossibility of transport by team over 300 miles of drought-stricken country to the nearest railway.

The water supply at this period became so restricted that armed patrols guarded the only available tank, and doled out a scant daily allowance to the residents. Travellers were allowed but one drink for themselves and horses.

Significant of the changed conditions is the fact of continuous operations during the present disastrous and protracted drought.

Cobar, like Broken Hill, affords a striking object lesson of the vital influence which mining exerts on the material progress and prosperity of a country. What other industry can compete with the rapidity of the restless energy with which it overcomes tremendous difficulties and reclaims arid tracts to civilisation?

During the operations of the Company from 1876 to 1893, 213,182 tons of ore were raised, 23,610¾ tons of copper produced, and £154,000 was paid in dividends up to 1889. Further dividends have been paid under the present tribute, raising the total amount to £202,000.

Geological and Descriptive.—In 1880 the Writer accompanied the late L. H. G. Young, Geological-Surveyor to Cobar. From the report published by the latter in the Annual Report of the Department of Mines for the year mentioned (p. 262), the following notes are extracted:—

"The workings are on what is known as the west lode. On the surface there appear the outcrops of two adjacent parallel lodes. It is my opinion, however, that all three form one lode, being only separated by pieces of country known to miners as 'horses.'

"The characteristic point in the Cobar Mine is the great variation in the width of the lode, namely, from a mere film to 100 feet. . . . . .

"The ore from the 50 fathom level is composed of solid yellow sulphide of copper; from the 39-fathom level, of carbonates, metallic copper in films, red oxide, grey sulphide and brown iron ore, the lode being fairly compact.

"At the 26-fathom level the ore is principally carbonate of copper, mixed with iron ore, while the lode is less compact."

The physical features of Cobar may be briefly described as a monotonous stretch of level country, above which a few hills and ridges of low elevation rise conspicuously. Cobar lode forms a low ridge, having a north and south trend. Fort Bourke and the Peak ridges, of greater elevation and length, have parallel trends south and east of the former. The country consists of sandstones and slates of probably Silurian age. On the Geological Map of the Colony, the elevated peaks have hitherto been coloured as Devonian, but from the Writer's observations, and the identification of Silurian fossils by the Palæontologist, Mr. W. S. Dun, in similar rocks at Bobadah, and also in the limestone between Cobar and Nymagee, as well as the extreme lithological contrast between the highly cleaved and folded rocks, and the outliers of approximately horizontally bedded sandstones and conglomerates—noted particularly between Mount Hope and Euabalong, and at Mount Boppy—it is more than probable that the Cobar rocks are older than Devonian.

To the north-west of Cobar, on Mount Grenfell Station, Mr. C. A. Chesney, C.E., obtained undoubted Devonian marine fossils, but the site has not yet been geologically examined. It will probably prove an outlier similar to those already alluded to.

GREAT COBAR COPPER MINE.

(90-fathom level. Massive sulphide ore in face.)

The elevated areas at Cobar are the direct result of mineralisation, the indurating influence of which has rendered them less amenable to subærial disintegration and degradation than the surrounding country. This feature possibly lessens the prospect of any extensive metalliferous deposits occurring in the level country. The principal indurating agencies in the high metalliferous areas are silica and iron. Infiltrated masses of the former are conspicuous at Fort Bourke Hill, where massive sandstones have been converted into quartzite by the investing silica. The slates of these regions are highly ferruginous.

Outcrop.—Contrary to the general idea, the Cobar copper lode did not make a really strong outcrop. In only one place, near the site of the native well, did copper ores show at surface. Three small patches of iron oxide were exposed—two near the well, the third at the site chosen for "Renwick's Shaft." The outcrop consists chiefly of highly ferruginous slate, which, in the case of the "middle" and "eastern" lodes (2½ and 4½ chains east of the main lode) is highly silicified. The "middle" lode only has been pierced below ground in a crosscut extended 140 feet from the 54 fathom level at the north end of the main workings, and also from the 34-fathom level near Becker's shaft. Twenty-one feet of mineralised slate in one instance and 30 feet in the other, were passed through, constituting good concentrating lode stuff (yellow copper ore).

In 1885 horizontal drill bores of 330 and 238 feet were also put in east from the 39-fathom levels, in Sections 16 and 19, in search of the parallel eastern lodes, but nothing more than 10 or 11 feet of quartz, at a distance of 200 feet east, was encountered in the slate country. Possibly blanks occur as in the main lode.

The comparatively small outcrops of gossan on the main lode afforded little indication of the immense ore bodies below; neither does the outcrop of the "middle" lode betray the slightest surface evidence of its cupriferous contents beneath. Hence there is reason for anticipating the occurrence of payable ore bodies, possibly of considerable extent in both the "middle" and "eastern" lodes, which are as yet practically intact. Both these lodes possess strong outcrops of ferruginous slate and quartz. South of the main shaft a crosscut was driven 90 feet east, but this was insufficient to reach the "middle" lode; crosscuts at least 330 feet long are necessary to intersect the two eastern lodes.

Development—The position of the mine, six years after the formation of the Company, is best presented by reproduction of the following extracts from a report furnished to the Under Secretary for Mines by the General Manager, Mr. George Hardie, published in the Ann. Rept. of the Dept. of Mines, 1878, p. 24.

"Three distinct lodes run through the property, known as the "east" lode, "middle lode," and "west lode". Operations thus far have been confined to the "western lode," upon which four shafts have been sunk—"Becker's" to 324 feet, "Barton's" to 324 feet, "Hardie's" to 214 feet, "Renwick's" to 286 feet."

"Becker's Shaft.—Good ores exist from the surface to the bottom. At the 26-fathom level the lode in the shaft is 24 feet wide, composed of carbonates and grey ores. At this level drives have been put in north 130 feet, and south 270 feet, proving the lode to be on an average 18 feet wide, and worth 14 per cent. At 39-fathom level drives have been put in north 90 feet and south, 110 feet, the lode averaging 12 feet throughout of good ores. At the 54-fathom level the lode is proved to be at least 17 feet wide of sulphurets, worth 22 per cent."

"Barton's Shaft is 600 feet south of Becker's. At the 15-fathom level drives have been put in 191 feet, the lode averaging 15 feet of good carbonates. At the 26-fathom level drives have been put in north, 180 feet, and south, 161 feet—the lode throughout these drives will average 40 feet wide of grey, carbonate, and oxide ores of good quality. At the 39-fathom level drives are in north, 136 feet, and south, 80 feet, the lode throughout being fully 15 feet wide, with 14 per cent. At the 54-fathom level the same sulphurets precisely have been cut as in Becker's shaft at the same level."

"Hardie's Shaft, 180 feet south of Barton's, is down 214 feet, with good ore to be found in every winze and drive."

"Renwick's Shaft, 260 feet south of Hardie's, is connected with Hardie's at the 15 and 26 fathom levels, proving the existence of first-class ores. No work has been done south of Renwick's shaft."

"Barton's Shaft is the main shaft, and is fitted with skids and cages to the 54-fathom level. A 40-horse power engine does all the hauling, works the ore breakers, also rollers for crushing fireclay, and saw-mills, etc.; and in due time will work one of Handcock's patent jiggers specially designed for treating poor ores."

"Furnaces.—There are eight furnaces in full work—six reducing, one roasting, and one refining. The present output is about 40 tons of fine copper per week. Additional furnaces are being erected with all speed."

"Tanks.—The company has expended several thousand pounds in conserving water, and has just completed a 10,000-yard tank in addition to their previous supply."

"Output.—The output of the past year is 1,463 tons of fine copper, valued at £88,000."

"This mine has been at work three and a half years, during which period 18,993 tons of ore have been smelted, yielding 2,683 tons of refined copper (which assays 99·5 to 99·60 per cent.), valued at £160,980."

The population of Cobar at this time was estimated at 1,000. The accompanying plan and section of the underground workings will reveal the present aspect of the mine. The deepest shaft is 90 fathoms (540 feet). From this level drill bores were put down diagonally to a depth of 120 feet, proving a width of lode equal to 40 feet, and the ore tenor about 4 per cent. copper. Water was struck at 601 feet in the bore. At the north end the Cobar lode splits; the eastern branch made into good ore, but the western has not been followed. The present working faces at the 74 and 90 fathom levels equal 50 feet each in width, increasing in some places to 70 feet, of solid iron sulphides, containing varying proportions of copper pyrites.

The oxidized zone extends to about the 250-feet level. Though a small proportion of oxidized ores is still being obtained from this zone, the visible supply has been practically exhausted.

Winning the Ore.—Wherever possible, the Cobar Syndicate has wisely adopted the contract system in stoping and trucking below ground, with satisfactory results to both parties. Drilling is principally performed by compressed air drills, though a few contract parties are still using hand drills. The contract price for mining is about 4s. per ton. The output amounts to about 2,000 tons per week, but will shortly be considerably augmented, as two additional blast furnaces are being erected to compete with a larger output during the remainder of the syndicate's tributing tenure. The output, however, cannot be increased beyond a moderate total, because of the limited shaft room.

Though electric lighting has been installed above ground, it has not yet been introduced below. The adoption of ordinary coal miners' oil lamps, however, is a considerable advance on candles, both as regards light and convenience, especially for the truckers.

Haulage is necessarily comparatively slow, owing to the very restricted dimensions of the two working shafts. On reaching the surface the loaded trucks are run to the heap-roasting ground on the east fall of the ridge, close to the shafts, and their contents dumped directly on to the heaps in course of preparation.

Since the advent of blast-furnaces the old tips have been turned over and carefully sorted, the great bulk of the discarded material being turned to advantage, as it served admirably for fluxing purposes, yielding at the same time its quota of valuable metal. Likewise from the earlier fillings below ground, and from the walls of the lode, much low grade, yet workable ore, has been extracted, which was discarded or left whilst following the richer central portions of the lodes.

Composition of the Ores.—The composition of the rich ores from the upper levels may be well studied in the following analyses made by Mr. W. A. Dixon, F.C.S., F.I.C. (Ann. Rept. Dept. Mines for 1878, pp. 25–29.) It will be observed that bismuth was present in marked quantity, but apparently the major portion of it was eliminated during smelting operations, as revealed by the analysis of the copper produced from the ores analysed (No. 65). It is noticeable that in a recent analysis of drillings from the 50, 74, and 90 fathom levels (sulphide zone) its presence was not detected. Possibly it may be confined to certain regions of the lode, and in the oxidized zone leaching and re-deposition may have concentrated it in appreciable quantities.

With a view of increasing the malleability of the Cobar copper, about 400 tons of Nymagee regulus was once purchased to mix with it to reduce the effects of the bismuth, Nymagee ore being practically free from this injurious associate.

On the walls of the lode, at the present working levels, a little zinc-blende and galena make at intervals, which are roughly discarded at the surface.

Analyses of Cobar Copper Ores, by W. A. Dixon, F.C.S., F.I.C., made for the Department of Mines, N. S. Wales, 1878. (*Vide* Annual Report, Department of Mines, 1878, pp. 25–29.)

Assay Numbers.	56	57	58	59	60	61	62	63	64	65
Silica	4·26	2·06	·62	1·92	·96	20·68	·56	10·64	29·28	....
Copper	22·84	54·06	87·87	54·93	26·47	63·24	57·42	42·79	38·23	99·346
Antimony	·61	Traces	Traces	Traces	·46	·13	Traces	..	..	·029
Bismuth	2·11	1·47	1·90	2·58	2·17	1·18	·95	1·24	·21	·419
Lead	·27	·41	·45	..	..	..	7·79	..	..	·086
Arsenic	Traces	..	..	..	..	..	..	..	..	·011*
Iron	39·20	7·28	30·80	18·26	39·09	1·74	4·99	8·49	·78	·083
Zinc	·35	..	..	..	..	..	..	..	..	....
Silver	Traces	Traces	..	..	..	..	..	..	..	·026=8 oz. per ton.
Nickel	..	Traces	Traces	..	..	..	..	..	..	....
Magnesium	..	5·33	..	..	..	..	Traces	..	..	....
Sulphur	24·11	4·18	18·63	14·48	27·46	5·70	11·67	..	..	....
Carbonic acid	..	9·97	..	..	..	Traces	5·87	14·37	17·47	....
Water	..	3·41	..	..	..	..	4·60	7·04	3·79	....
Water, oxygen (less water), loss, undermined, &c.	6·25	11·33	10·00	7·83	3·39	7·33	6·15	15·43	10·24	....
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·000

* Traces of arsenic, nickel, cobalt, gold, loss, &c.

Sample 56—Copper pyrites and magnetite.
„ 57—Red oxide, copper glance, and ferric oxide.
„ 58—Copper pyrites, red oxide, and ferric oxide.
„ 59—Copper glance with ferric oxide.
„ 60—Copper pyrites and magnetite.

Sample 61—Copper glance and red oxide.
„ 62—Copper glance with malachite.
„ 63—Malachite with ferric oxide.
„ 64—Azurite.
„ 65—Copper from the above.

The nature of the sulphide ores at Cobar is partially revealed by the following analysis made in the Departmental Laboratory from drillings obtained by the Writer through the courtesy of Mr. T. Longworth, of the Cobar Syndicate. The sample was intended to represent an average of two days' drillings at the 50, 74, and 90 fathom levels; the copper contents, however, may be disregarded, as they do not represent the average value of the ore in these levels, which according to the smelting returns ranges between 3·2 and 4·4 per cent. :—

Moisture at 100° C	0·20
Metallic iron	42·65
,, copper	10·15
,, lead	trace
,, zinc	,,
Silica	16·09
Alumina	0·44
Lime	absent
Magnesia	0·34
Sulphur	20·74
Sulphur trioxide (SO_3)	0·23
Oxygen (by difference)	9·16
	100·00

Silver, at the rate of 1 oz. 21 dwt. 21 grs. per ton.
Gold, a trace (under 2 dwt.) ,,

Note.—A large amount of magnetite is present in this sample.

The proportion of iron is complicated by the admixture of fragments of metallic iron broken from the drills, which could not be removed without loss of a portion of the magnetic pyrites present.

Preliminary treatment of the Ores.—Though the Cobar sulphides are eminently suitable for pyritic smelting, the syndicate has not deemed the advantage thus gained sufficient to induce it to incur the cost of providing a hot blast, without which pyritic smelting cannot be efficiently maintained.*

As the ore comes from the stopes it is piled on the roast-heaps without extra care. In forming the roast-heaps the V system is roughly followed; sufficient space being left between two adjacent heaps to admit of a third V-shaped filling between, when the former are underway. A rough foundation of wood is laid down, and in the case of the later-formed central heap, it is carried up the sides of the adjoining heaps. Apparently little attention is paid to flues for ventilation, doubtless the large size of the ore-blocks afford sufficient in the cavities between them to obviate the necessity of special preparation to secure it. The heaps take an elongated form from the raised tramway used for stowing, and contain from 2,000 to 4,000 tons. A little ragging is spread on the tops, but scarcely any on the sides. The fines apparently are little used for covering, being mostly roasted separately in a circular kiln excavated in the outcrop.

The absence of sufficient covering accounts for the evidence of too great heating in parts of the roast-heaps, where fusion has taken place to a considerable extent. About three weeks are allowed for a roast (according to Mr. Longworth, the managing shareholder). The roasting heaps are well situated on sloping ground, which affords excellent drainage. The natural aridity of the climate disposes of the necessity for provision being made for recovery of copper carried away as soluble salts from roast-heaps during rainy weather.

Owing to the long campaign with reverberatory furnaces at Cobar, the country has been devastated of suitable firewood for a radius of many miles. The wood required for heap-roasting costs 15s. per ton for dry 5-feet lengths,

* Arrangements are now being made for adoption of pyritic smelting.

GREAT COBAR COPPER MINE.

(90-fathom level. Stoping with compressed air drills.)

and 12s. 6d. for green. The consumption of firewood in the reverberatory furnaces averaged about 70,000 tons per annum. In 1889 a trial was made with coal from one of the top seams of the Dubbo Coal-fields (Ballimore?). Mixed with wood it answered fairly well in a reverberatory furnace, and about equally as well mixed with charcoal, in the blacksmith's forge.

Smelting.—The furnace charges consist generally of the following proportions:—

8 cwt. of raw sulphides.
8 ,, of calcined sulphides.
4 ,, of oxidized ores, slate, dry gold and silver ores, &c.†
4 ,, of coke.

The first reduction brings the matte up to about 30 to 35 per cent. tenor, in which form it is sent to the Syndicate's roasting and refining plant at Lithgow, where some sixteen reverberatory furnaces are in use.

The smelting-plant at Cobar consists of four 80-ton water-jacketed blast-furnaces, with a working capacity of about 120 tons per twenty-four hours, but it has already been announced that two additional furnaces are to be at once erected.

Gold in Cobar Copper Ores.—Though gold was early known to be present in the Cobar Mine, and in a free state was occasionally noticed in the oxidized ores, no attempt was made to turn it to account until the present syndicate began operations in 1893–4. In 1882 Mr. Russell Barton secured a specimen of malachite showing coarse gold, and the Company's caretaker (Mr. W. Gillard) has in his collection a specimen of slate from near the outcrop containing a rich seam of scaly gold.

In 1881 an assay was made in the Departmental Laboratory of a sample of the Cobar copper obtained by boring through several ingots, with the following results:—

Gold	2 oz. 12 dwt. 4 grs. per ton.
Silver	1 ,, 5 ,, 0 ,, ,,
Copper	92·65 per cent.

As these results were made known at the time it appears strange that no advantage was derived from the knowledge. Cobar copper, for years, must have proved a lucrative investment for metal-buyers in England, who secured it at a lower market rate than Chilian bars, notwithstanding its valuable gold contents. Possibly the difference in market value between the Cobar and Chili metals was sufficient to defray cost of further refining, leaving the precious metal as clear profit. Mr. Russell Barton (at one time Chairman of the Company) attributes the omission to the fluctuating results of tests of the surface ores, portions of which gave fair gold value, others almost negative results, a natural outcome of the leaching and re-precipitating processes to which the upper levels of the lode had been subjected. As gold is less susceptible to natural leaching solutions than copper, it remains to enrich the more gossany ores from which the copper had been wholly or in part removed. The re-precipitated or secondary copper ores would thus become richer and more concentrated, but impoverished in gold, hence the fluctuating returns of assay samples, which appear to have depreciated the importance of the presence of gold, even in small quantities, in the ores, notwithstanding the well-known collective influence of metallic copper on the precious metals in smelting. Mr. Barton states that the gold contents

† When slag from the forehearths is used—about every second charge—it takes the place of this item.

of the copper produced during early operations varied from half an ounce to 3 oz. per ton. Not till the latter half of 1894 did the Company draw the attention of buyers to the presence of gold and silver in their copper in recoverable quantities. The immediate result was an advance of about £7 per ton over the current quotations for Chili bars.

The sulphides from the present working stopes are reported to yield from $2\frac{1}{4}$ to 3 dwt. of gold per ton. Concentration at the present day is extreme compared with past operations, and probably the average proportion of gold in the sulphides, though lower, is more constant and even than was the case in the oxidized ores. In smelting 10 to 20 and even 30 per cent. ores, concentration is very slight compared with smelting ores of a 3 or 4 per cent. tenor, hence the gold and silver contents are considerably higher in the metal produced from the latter. The market value of the Cobar copper is now enhanced some £20 odd per ton by the contained gold and silver. This great enrichment is not due, however, solely to concentration of the indigenous gold of the Cobar Mine, for the quantity is largely augmented by use of gold and silver ores from other mines as fluxes in the blast-furnaces; and herein lies the great potentiality of the pure iron and copper sulphides of Cobar; their importance as fluxing bases for dry (silicious) gold and silver ores cannot well be over estimated. At the Peak, about five miles south of the copper-mine, the Cobar Syndicate has secured a gold and silver mine (Conly and Barrass's), and is working it in conjunction with the former. The better class of gold ore is treated in a battery locally; the lower grades, which, however, are fairly rich in silver—containing about 30 oz. per ton and 3 dwt. of gold—are carted to the smelting furnaces for fluxing purposes. The Peak lodestuff consists of soft rotten slate, with harder cherty bands and quartzite; in the ferruginous joints and cavities silver-chloride is freely visible.

The sulphides of Cobar consist largely of pyrrhotite (magnetic pyrites) composition Fe_7S_8 = iron = 60·5, sulphur = 39·5, with pyrite, and chalcopyrite composition (Cu_2S, Fe_2S_3 = iron = 30·5, copper = 34·6, sulphur, = 34·9) equivalent to a smelting return of about $3\frac{3}{4}$ to $4\frac{1}{2}$ per cent. of copper. They are comparatively very low in silica—16·09 per cent.—according to the analysis of the drillings already quoted; though not approaching the unique purity of Mount of Lyell ore in this respect. The importance to the field of the low percentage of silica in the immense sulphide deposits of the Cobar Mine cannot be over-estimated, as it affords a cheap and efficient means of extracting the gold and silver contents of some of the neighbouring mines, especially those in which copper occurs too sparingly for separate metallurgical treatment, yet too pronounced for ordinary battery or cyanide processes. Silica is necessary in the furnace charge to combine with the abundant iron of the sulphides to form a fluid silicate of iron slag. The silicious gold and silver ores of the adjacent mines are just what is requisite for proper fluxing requirements. According to Dr. Peters, Junr.,* a silicious schist or slate in itself is preferable to pure silica (quartz) in matte roasting and doubtless also in reducing. The advantage to a smelting company of being able to command silicious flux having of itself intrinsic value is immense, whilst an equivalent benefit is derived by the owners of such ores. In some public smelting works a mutual gain is derivable from payment of the actual value of the gold and silver contents of dry silicious ores, without deductions other than freight, in return for the necessary flux thus obtained almost free of expense.

* Modern Copper Smelting, 5th Ed., 1892, p. 271.

Great Cobar Copper Mine.
(90-fathom level. Lode, 70 ft. wide.)

If the cost of railway transport* could be so reduced as to enable matte-roasting to be carried on profitably at Cobar, the amount of dry gold and silver ores for fluxing purposes could be further increased. The large fluxing base at the command of the Cobar Company opens up the most extensive problem of the field. Large as is the scale on which operations are now conducted, they are capable of still further development. However unpopular the idea of huge trusts and combines may be in the public mind, there is no question that only under such conditions of consolidation will some of the extensive low-grade cupriferous gold and silver deposits of the vicinity be turned to greatest account. For though at present the Cobar Chesney Mine is the only other of the Cobar group that has developed copper ores of commercial importance, there is every reason to anticipate, at all events, an amount of copper ore in the lower levels of the others sufficient to render unprofitable any method of extraction other than smelting in the way indicated.

If combination be eschewed an alternative scheme presents itself to the owners of the deposits mentioned, viz., utilisation of the Cobar furnace slags for fluxing purposes, as these are capable of absorbing a further amount of silica. The proper proportion of silica in blast-furnace slag according to Dr. Peters (Modern Copper Smelting, 5th edition, 1893, p. 185) lies between 24 and 36 per cent., and may be raised or lowered about 6 per cent. without seriously affecting the running of the furnace, but every unit in excess will reduce the amount smelted in 24 hours. Taking the maximum limit—36 x 6 = 42 per cent. can be absorbed without serious inconvenience, and it is well known that this limit is frequently exceeded. The above authority in the 7th edition of the same work p. 282, states that "probably the most silicious slag made regularly in the world in blast-furnaces, is that of the Saengerhausen Smelter on Mansfeld ores of Prussia, viz., 53·83 per cent. of silica."

Robert Sticht, of Montana, U.S., in an article on pyritic smelting, contributed to Peter's Modern Copper Smelting, 7th edition, p. 402, states that "the amount of silica in the slags may vary from below 28 to above 48 per cent., to suit the ores treated." Hence with pyritic smelting at Cobar, the amount of silicious flux may be largely increased, especially if in addition the amount of sulphur be so regulated as to avoid the formation of excess of protosulphide of iron in the matte, leaving the protoxide of iron free to combine with the silica, instead of with the excess of sulphur, over and above the amount required to satisfy the copper. The proportion of sulphur to copper in subsulphide of copper is 1 to 4, whilst that of sulphur to iron in ferrous subsulphide is 1 to $1\frac{3}{4}$.

Herbert Lang (Matte Smelting, 2nd ed. 1898, p. 37), states that "slags have been, and are being made in practice which contain as much as 65 per cent. of silica." In reverberatory furnaces a high proportion of silica can be slagged off.

A slight insight into the value of the Cobar slags for fluxing purposes may be gained from the following analyses of samples taken at random by the Writer:—

	Copper.	Silica.	Iron.	
From reverberatory slag dump	0·66 per cent.	35·49 per cent.	41·40	(FeO 53·22 per cent.)
" blast-furnace "	0·20 "	27·31 "	45·28	(FeO 58·21 ")
" " forehearths	0·31 "	29·29 "	44·14	(FeO 56·75 ")

Whilst on the subject of gold extraction, one other step in advance may be indicated, viz., electrolytic refining of the copper, and separation of the gold and silver contents, the absence of which at present entails a reduction

* Freight on coal and coke, Lithgow to Cobar, 16s. per ton; freight on matte to Lithgow, 14s. 8d. per ton; freight on copper, Cobar to Sydney, 41s. 3d. per ton; freight on copper, Lithgow to Sydney, 12s. per ton.

of £4 per ton in the value of the copper, as a set-off against cost of extraction. Such a plant would, perhaps, be most advantageously situated at Lithgow in connection with the roasting and refining works already established, where coal is obtainable on the ground. In the absence of cheap water power for generating electricity, it is, however, doubtful if the cost of extraction could be lessened locally. This, however, is purely a financial question.

The following particulars are extracted from a report by Mr. John Munday to the Chairman of Directors of the Great Cobar Copper-mining Company, Ltd., dated August 7th, 1897. The condition of the mine, and the longitudinal and lateral extensions of the ore bodies at this date, can be readily grasped from the reliable figures quoted :—

"In the shallow ground there are workings on the lode to an extent of 1,300 feet in length. Below the 37-fathom level the ore is separated into four bodies, striking vertically downward.

"The northernmost of these ore bodies is situated near Becker's Shaft, and is 130 feet long, averaging 20 feet wide, and has been worked out down as far as the 54-fathom level. This body of ore has also been sunk upon by Becker's Shaft to the 74-fathom level, but is otherwise intact.

"The middle ore body commences at 260 feet south of the above, and extends southward in length 320 feet, and at the 70-fathom level stope, where its dimensions are best ascertained, its average width is not less than 40 feet. In the middle of the stope its greatest width is over 70 feet. Barton's Shaft is sunk on this bunch of ore, and the present 74 and 90 fathom level stopes are opened on it.

"In the southern ground the lode forms two branches, developing two separate ore deposits. The deposit on the eastern branch commences at a distance of 130 feet southward from the middle ore body, and that on the western branch at 170 feet. The ore in the eastern branch is 68 feet long, by an average of 25 feet wide, and that in the western branch 68 feet long by 10 feet wide in the bottom of the 54-fathom level. These masses of ore have not been touched below the 54-fathom level. . . . . . .

"In development work the 90-fathom level drive north has been extended to a distance of 100 feet from Barton's Shaft, and the 90-fathom level south 50 feet; both faces in ore ground.

"The 70-fathom level drive north is now distant from Barton's Shaft 310 feet, and the south drive 250 feet. The north drive is opened beyond the extent of the back stope 83 feet into the less productive ground situated between the deposits of ore, the lode in the face of the drive being 4 feet wide. The south drive at this level, since leaving the middle deposit, has also been driven in unproductive ground, but there are at present indications of ore in the end.

"East Lode.—At the 34-fathom level a crosscut put out eastward from the main lode near Becker's Shaft, intersected, in a short distance, the western wall of the separate formation known as the east lode. This lode has been driven across over 30 feet, the ore obtained from it being taken to the smelters. It does not present a solid sulphide mass such as is shown by the main lode, but its structure is of a more laminated character, and its composition slaty, resembling the country rock. The layers of ground in the lode dip with its underlay, and are intercalated with seams of ore and seams of quartz.

"What is probably the same lode was discovered some years ago in the 54-fathom level eastward from Becker's Shaft, where its width was found to be 21 feet, and where its composition is very much the same as that of the 34-fathom level lode, except that the veins of ore in the slaty matrix take a more defined sulphide form. . . . .

GREAT COBAR COPPER MINE.
(Water Jacket Blast Furnace, 80-ton.)

"In addition to the ore ground developed in the main lode, there is the ore in the east lode already referred to, and there are within 300 feet to the east, two parallel mineral outcrops, which afford very promising scope for exploration."

Memo. of percentages of ore smelted at Cobar to 3rd August, 1889.

Half-year ended.	Ore.	Equal to. Copper.	Percentage.
	tons.	tons.	
31 Dec., 1876	1,458	174	11·93
30 June, 1877	2,350	255	10·85
31 Dec., 1877	2,530	268	10·59
30 June, 1878	3,651	600	16·43
31 Dec., 1878	4,738	857	18·08
30 June, 1879	5,610	876	15·61
31 Dec., 1879	7,005	1,015	14·48
30 June, 1880	8,334	1,181	14·70
31 Dec., 1880	11,890	1,388	11·67
30 June, 1881	9,930	1,163	11·71
31 Dec., 1881	11,622	1,405	12·08
30 June, 1882	5,882	942	16·00
31 Dec., 1882	5,820	863	14·82
30 June, 1883	6,772	955	14·10
31 Dec., 1883	11,324	1,460	12·89
30 June, 1884	11,876	1,361	11·46
31 Dec., 1884	12,003	1,408	11·73
30 June, 1885	11,558	1,064	9·20
31 Dec., 1885	12,000	1,066	8·88
30 June, 1886	14,000	1,093	7·80
31 Dec., 1886	11,887	951	8·04
30 June, 1887	10,840	883	8·01
4 Feb., 1888	9,000	705	7·83
30 June, 1888	5,500	416	7·56
31 Dec., 1888	7,425	589	7·09
3 Aug., 1889	8,177	667¼	8·15
Totals	213,182	23,610¼	Average 11·07

Return of ore smelted and copper produced by the Great Cobar Copper-mining Syndicate at the Great Cobar Copper Mine:—

Period.	Tons ore smelted.	Tons refined copper produced.	Percentage.
1895	38,278	1,694	4·42
1896	63,185	2,703	4·09
1897	64,262	2,492	3·87
1898	111,557	3,520	3·24
	277,282	10·414	

RICHARD READ,
Managing Director.

Bringing the total production to the end of 1898 (plus a small unrecorded quantity produced in 1894) up to 490,464 tons of ore, which yielded 34,024¾ tons of copper.

Dividends paid to 28th December, 1898.

1 March,	1880,	1st,	of	2s. 6d.	7 March,	1895,	17th,	of	0s. 6d.
1 May,	1880,	2nd,	„	2s. 6d.	24 July,	1895,	18th,	„	0s. 6d.
14 July,	1880,	3rd,	„	2s. 6d.	16 Oct.,	1895,	19th,	„	0s. 6d.
1 Sept.,	1880,	4th,	„	2s. 6d.	22 Jan.,	1896,	20th,	„	0s. 6d.
14 March,	1881,	5th,	„	2s. 6d.	15 April,	1896,	21st,	„	0s. 6d.
8 June,	1881,	6th,	„	2s. 6d.	15 July,	1896,	22nd,	„	0s. 6d.
5 Sept.,	1881,	7th,	„	2s. 6d.	26 Aug.,	1896,	23rd,	„	0s. 6d.
1 March,	1883,	8th,	„	2s. 6d.	25 Nov.,	1896,	24th,	„	0s. 9d.
2 April,	1883,	9th,	„	2s. 6d.	3 March,	1897,	25th,	„	1s. 0d.
16 April,	1883,	10th,	„	2s. 6d.	9 June,	1897,	26th,	„	0s. 9d.
3 May,	1883,	11th,	„	2s. 6d.	8 Sept.,	1897,	27th,	„	0s. 9d.
6 June,	1883,	12th,	„	2s. 6d.	22 Dec.,	1897,	28th,	„	0s. 9d.
28 Aug.,	1883,	13th,	„	2s. 6d.	31 March,	1898,	29th,	„	1s. 0d.
30 Nov.,	1883,	14th,	„	2s. 6d.	29 June,	1898,	30th,	„	1s. 0d.
6 June,	1884,	15th,	„	2s. 6d.	21 Sept.,	1898,	31st,	„	1s. 0d.
31 Dec.,	1888,	16th,	„	1s. 0d.	28 Dec.,	1898,	32nd,	„	1s. 6d.

Making a total of £202,000 paid in dividends since the formation of the company, equal to £2 10s. 6d. per share to the original shareholders, apart from the large profits of the present tributing syndicate.

Great Condobolin Gold and Copper Mine, L., Condobolin Dn. (*See* Condobolin Mine.)

Green Swamp. (*See* Glanmire.)

Great Wheal Burril Consols Copper Mine, M., Wellington Dn., Burril Ranges, nine miles from Wellington.—This property formed the subject of a dispute brought before Parliament in 1873. The matter being disputed mineral selections by Burns, Philp, & Co., embracing Mylecharane's Lode, Muddy Creek, on Burril or Booral Run. Copper ores in the Australian Museum, purporting to have come from a depth of 45 ft. in a 30-ft. lode, are labelled with this name, but nothing authentic is known of the deposit.

Great Western Copper-mining Company, B., Orange Dn., Icely, near Byng.—The prospectus of this company, issued by Mr. S. L. Bensusan in November, 1872, embraced a number of lodes previously opened and partly worked near Byng and Lewis Ponds. The first half-yearly report, dated February, 1873, enumerated these as follows:—The Britannia, Icely, Belmore, Moonta, Nelson, Gurophian, East Block Mines, and other property to the south. (*See* Carangara Mine.)

In the Mineral Statistics, $\frac{1876}{p.\ 91}$, it is stated that the Company was working the following lodes at Icely, viz.:—The "Williams" lode having a thickness of $2\frac{1}{2}$ ft. at surface, 5 ft. at 125 ft., and 3 ft. at 270 ft. Strike N. 30° W., dip easterly; 4,000 tons of ore raised yielded 560 tons of copper.

The Icely Lode was proved to a depth of 125 ft.; average thickness, 1 ft. 6 in. Strike N. 30° W., dip 1 in 6 easterly; 1,000 tons of ore raised yielded 100 tons of copper.

The Company held several other lodes, four of which had been worked, the strikes and dips being similar to the Icely and Williams Lodes; 100 tons of ore raised from them yielded 12 tons of copper.

The Company was also working eight lodes at Lewis Ponds Creek; average thickness, 3 ft. Strikes N. 20° W., and dips about 1 in 5 easterly; proved to 168 ft.; 4,000 tons of ore raised yielded 640 tons of copper.

According to Captain W. R. Reynolds, at one time mine-manager for the Company, smelting-works were erected in connection with the Icely Mine, at which the ores from the others were treated. The Company also purchased ores at the rate of 10s. per unit for all over 4 per cent., the latter amount being deducted in lieu of smelting charge.

Captain Reynolds also supplied the following particulars of the mines that came under his supervision during the operation of the company, which were worked chiefly by contract instead of day-labour :—

		Opened to.	Thickness of lode.
Icely		275 ft.	1 to 4 ft.*
Ophir	about	200 ,,	6 in. to 5 ft.
Gurophian (afterwards Tom's Lewis Ponds)	,,	170 ,,	9 ,, to 4 ,,
Britannia	,,	210 ,,	3 ,, to 5 ,,
Belmore	,,	180 ,,	1 ft. 6 in.
Moonta	,,	60 ,,	....
Nelson	,,	120 ,,	1 ft.

* Worked ten years.

Mr. Danvers Power states, that at the Mt. Fraser Mine, near Byng, a new shaft has been sunk 110 ft.; driven south 109 ft., north 100 ft., with rise to meet winze in old workings. P.G. 14; sample along 110 ft. level of good ore, 8 in. wide. Assayed by Mr. A. Orr; yielded copper, 6·46 per cent.; silver, 1 oz. 13 dwt. 6 grs. No gold.

Grogan and Singleton's Copper Mine, S., Captain's Flat Dn.—This property consists of a 40-acre lease adjoining the Old Commodore Vanderbilt Mine. Mr. H. Wood, late Under Secretary for Mines, who inspected the mine in connection with the Prospecting Vote, reported the lode to have a thickness of from 4 in. to 18 in., a meridianal strike, and well-defined walls. Three tons of ore raised during sinking operations to 75 ft., and driving 20 ft. from the 45-ft. level, were tested at the Clyde Smelting and Chlorination Works, with the following results :—

Smelters assay—Metallic copper	29·59 per cent.
Chemical ,, ,,	31·19 ,,
Silica	22·17 ,,
Silver	10 dwt. 21 grs. per ton.
Gold, a trace (under 2 dwt.)	

Gulgong, M., Gulgong Dn.—From within three miles of Gulgong (probably from Isbester's Paddock, three miles south, where a broken lode was opened to 70 or 80 feet). Copper ores were sent for assay in 1895, Nos. 2,531–2 yielding from 25 to 32·67 per cent. of copper and 13 oz. 12 dwt. 4 grs. of silver per ton. In 1896 a sample purporting to come from a hill near the Canadian Lead, No. $\frac{2493}{96}$, yielded 35·67 per cent. of copper and 3 oz. 11 dwt. 20 grs. of silver per ton. Shaft sunk 40 feet. Fifteen hundredweight yielded 22 per cent. of copper at the E. and A. Copper Company's Works, Waratah.

Gumble, L., Molong Dn., Parish Gumble, County Ashburnham.—The Gumble lode affords one of the rare instances in the Colony of the association of tin and copper ores in the same lode; another instance described in this work is that of Bald Nob, near Emmaville. Unfortunately at Gumble neither metal is sufficiently represented to pay for working.

The most deceptive feature to miners in this lode is the dissemination of magnetic iron oxide in small grains, which imparts to it considerable gravity, and thus leads to the belief that the latter is due to cassiterite (tin oxide).

A concentrating test made at Parke and Lacy's works, Pyrmont, during operations at Gumble is reported to have been successful in producing concentrates containing 60 per cent. of tin and 15 per cent. of copper, but this statement is discounted by the absence of any data and the closing of the mine.

The following description is from the Report of the late Government Geologist, N.Z., C. S. Wilkinson, $\frac{1886}{\text{p. }132}$:—

"The lode commences at the junction of granite and altered Silurian slates, and traverses the latter for about 100 yards in a N. 30° E. direction. It varies in width from 1 to 8 feet, and consists of ferruginous felspathic and silicious lode-stuff, more or less impregnated with green and blue carbonates, grey sulphides, and red oxide of copper, brown oxide of tin, and magnetite. The tin ore principally occurs in the central and southern portions of the lode. . . . . .

"In a drive on the 100-feet level on the eastern side of the lode, for a distance of 15 feet, the country rock, altered rubbly shales, with serpentine in the joints, is found to be impregnated with native copper in bright crystalline small grains and scales; and on the west side, at the 60-feet level, the rock for a distance of 14 feet is in places stained with carbonate of copper. It is thus evident that the rock on both sides of the lode has been more or less affected by the agencies, probably thermal water holding minerals in solution, which formed the lode. . . . .

"Seven average samples taken by myself across the lode yielded on assay at the rate of copper traces to 2·85 per cent., tin traces, to 0·5 per cent., and silver traces to 4 oz. 1½ dwt. per ton.

"A sample of the country serpentinous rock showing native copper, assayed 4·2 per cent. of copper, with traces of tin and silver.

"One picked sample of brown ore showing tin oxide and carbonate of copper from the lode at the 60-feet level, south drive in the middle shaft, yielded on assay—copper, 3·85 per cent.; tin, 58·70 per cent.; silver, 8 oz. 19½ dwt. per ton; and no gold. It is thus seen that the ores occur in patches, and not disseminated regularly through the lode.

"Three-quarters of a mile south from the Gumble Mine, and at the line of junction of the Silurian and the granite, a lode somewhat similar to the Gumble lode occurs. It consists of soft felspathic lode-stuff, with yellowish-green silicate of iron, silicious clinker, and hard quartzite, with quartz veins containing pyrites and a little fluorspar, together with carbonates and sulphides of copper.

"About 20 chains further south occurs another outcrop of quartz containing carbonates of copper and fluorspar, which should be prospected."

Copper ore is also mentioned as occurring in altered slates and limestones about 1 mile north of Red Hill (1½ miles north of Gumble).

The Gumble Mine is again receiving attention, and it is reported that a trial parcel of 25 tons has been dispatched to Swansea.

Gundagai-Tumut District, T. & A. & L., Tumut, Adelong, and Gundagai Divisions.—In the vicinity of Gundagai, Adelong, and Tumut copper ores occur in numerous places, but in one only—Snowball Mine—in sufficient quantity to work. The following localities have been noted:—

Snowball (which see).

Red Hill, seven and twelve miles from Gundagai, ores assaying 6 to 11 per cent.

Mt. Parnassus, Gundagai, assaying 11·61 per cent.

Ph. Wagara, assaying 6·42 per cent.

Darbalara, in serpentine on the south side of Mt. Lightning, indications cut out at a shallow depth.

Back Station Creek, near Kimo, opened to 50 feet; pinched at that level.

Wyangle, in serpentine on Geary's property, assaying 26·60 per cent.

Brungle.

Adjungbilly Creek, in Tea-tree Gully, three-quarters of a mile south of Adjungbilly Creek.

Mingary Mt., about three miles S.E. of Snowball Copper Mine. Mr. Slee, Chief Inspector of Mines, reports strong stains of carbonate of copper and occasional pieces of gray and yellow ore, traceable for a considerable distance.

At Collingridge's Mine, Jones' Creek, near Gundagai. Native copper, rich in gold, occurs in the laminæ of slate.

Gunningbland Copper Lode, L., Parkes Dn.—On Gunningbland Run, near Trundle Road, about eighteen miles from Parkes.—Mr. E. C. Whittall, who recently inspected this lode, states that the copper ore—gray sulphide—occurs in the form of scattered threads and small bunches in quartzite, which is associated with limestone, sandstone, and conglomerate. A shaft has been sunk in the quartzite to 50 feet, to which depth no payable ore bodies had been discovered. A bold outcrop of ironstone occurs near by, stained in places with green carbonate of copper; this merits attention, as it may be the cap of a copper lode.

Gygederick Copper Mine, sixteen miles S.W. of Cooma, T. & A., Cooma Dn.—Mr. G. F. Litchfield, of Matong, states that about 1878 a shaft was sunk to a depth of 90 feet in a reported well-defined lode in the above mine, having a thickness of 2 or 3 feet. A quantity of ore was raised, but no particulars of its value are available.

Guyra, P. & U., Armidale Dn.—From ten miles east of Guyra a sample of massive copper pyrites was sent for assay, No. $\frac{1772}{98}$; which yielded 24·67 per cent. of copper and 14 oz. 6 dwt. 9 grs. of silver per ton.

Hall, T. & A., Queanbeyan Dn., Parish Gininderra, County Murray twenty-four miles S.E. of Yass.—Warden Maitland states that 10 tons of ore from this locality treated in Sydney yielded 14 per cent. of copper, and 8 dwt. of gold per ton. Mine now idle.

In the Yass Division of the Southern District, at Gooda Creek, Mr. J. B. Jaquet reported $\frac{1896}{p.\,138}$ that gold occurs in thin veins $\frac{1}{8}$ to $\frac{1}{2}$ an inch thick, composed of quartz, limonite, and copper carbonates. For 1 or 2 inches on either side of the veins the country rock is impregnated with gold.

Hampton, B., Oberon Dn., eighteen miles from Jenolan Caves, near Mount Victoria Road.—A deposit of bornite in chlorite has recently been discovered on Bull's Creek (which see). Samples have assayed over 34 per cent. of copper, with silver at the rate of 13 oz. 14 dwt. 9 grs. per ton, and 2 dwt. 4 grs. of gold.

Harrison's Mine, Copper Gully, Upper Bingara, P. & U., Bingara Dn.—Discovered and opened by W. H. Harrison in 1895, in slate and diorite (?) country near serpentine. Lode cut in shaft at 9 feet; thickness, 4 feet; assay value, low (2½ per cent.). Shaft sunk 35 feet, partly under aid; lode widened to 6 feet 6 inches, and increased in value to 9 per cent.

Hartwood Copper Mine. (*See* North Nymagee.)

Hayes, Jennings, and Party's Mine. (*See* Rosebrook.)

Honeybugle, L., Trundle Dn.—About sixteen miles west of the Bogan River at Dandaloo. Mr. L. H. G. Young in $\frac{1880}{p.\ 202}$ recorded the occurrence of a quartz reef stained with carbonates of copper in hornblende porphyry, at Honeybugle. Thickness of reef, about 14 inches; strike, N. 6° W.; dip, slight, to the W. Since that date a shaft was sunk about 80 feet, the country being hard and the reef small. Gold is present in the veinstone.

Hornsby Range, A., Broken Hill Dn.—About twenty-two miles from Broken Hill and eight miles from the Tarrawingee tram-line. According to the *Barrier Miner*, of the 13th July, 1898, a number of copper lodes were being opened at the above locality. A first parcel of 10 tons, of about 12 to 15 per cent. ore, had been prepared for shipment.

Hoy's Reef, Sandy Creek, P. & U., Tingha Dn.—Mr. J. Carthew, Inspector of Mines, reports that this reef consists of quartz with galena, zincblende, and copper pyrites, and has a thickness of 2 feet. Several other veins occur S.E. of it, one apparently larger. Strike N. 70° E., dip S. 20° E.

Icely Copper Mine. (*See* Great Western Copper Company.)

Invincible Copper Mine, A., Broken Hill Dn.—Eleven miles S.W. of Broken Hill and one and a half miles from Acacia Railway Siding. Mr. J. Hebbard, Inspector of Mines, reports Pros. Papers, $\frac{2188}{98}$, that three shafts have been sunk on the lode, the course of which is regular and well defined, and about 4 feet thick. The richest shoot has been worked to a depth of about 60 feet, when the shaft passed through it. A drive to the south proved the continuance of the lode in that direction, though poorer. Numerous indications of copper and other ores occur in the vicinity.

Ironbark Creek, P. & U., Barraba Dn.—Copper ores from this locality, Nos. $\frac{4457}{96}$ and $\frac{6797}{96}$, yielded 7·54 and 37·5 per cent. of copper.

Jacqua Copper Mine. (*See* Bungonia.)

Jaunta. (*See* Tuglow.)

Jerrickanora Creek, S., Braidwood Dn.—Several small finds of copper sulphide are reported in this locality.

Jindabyne Copper Mine, T. & A., Cooma Dn.—Portion 94, Parish Jinderboine, County Wallace; about four miles from Jindabyne, and about one mile from the Cooma Road.

Mr. Andrew Sturgeon, of Jindabyne, states that the principal work at this mine began about 1884, and that operations ceased about 1889, when many mines in the Colony were closed owing to the great fall in the value of copper. The shaft had reached a depth of about 80 feet, and samples taken down to that level yielded from 10 to 36 per cent. of copper. The lode at the bottom is reported to be of considerable width.

Under a provisional agreement with the owner, Messrs. Skidmore and Molesworth obtained from 3 to 22 per cent. of copper and 16 dwt. of gold per ton by assay from the accessible portions of the lode (the shaft having caved in), and from a large outcrop about ¼ mile to the south.

Jones' Mine, Mt. Morris, B., Rockley Dn.—About one and a half miles easterly from the Apsley Copper Mine, near Cow Flat, and about three miles from Lagoon; opened a number of years since, and ore despatched; is now being reopened, the shaft being 70 feet, and ore being raised.

Junee Reefs. (*See* Rockdale Mine.)

Kadumble Mountains, T. & T., Ironbarks Dn.—Carbonate and red-oxide of copper from these mountains are included in the Australian Museum Collection, but no particulars are available.

Kangaroo Mount, T. & A., Tumut Dn.—Copper ore was discovered by J. A. Harrison, about one mile from Mr. Owen's homestead, near the Mount. The apparent width of lode is reported as 6 feet at surface, in serpentine, carrying carbonates and sulphide, but only shallow prospecting by open-cut was attempted.

Keloshiel, B., Bathurst Dn., near the village of Eglinton.

Mr. James Ranken, of Bathurst, states that in 1850 his father had a small well deepened at the Keloshiel Brewery. In blasting the rock, pieces of dark-blue copper ore were obtained. Concerning this discovery, Mr. S. Stutchbury reported, on 12th April, 1852,* that "a copper lode was discovered by Mr. Ranken at this place [Keloshiel.—J.E.C.], while sinking a well for his brewery, at a depth of 20 feet. He showed me good specimens of green and blue carbonate of copper; and, as a proof that it must be of some extent, the water of the well continues so much impregnated with it as to render it unfit either for brewing or culinary purposes." No attempt has since been made to open up and prospect the source of the specimens and impregnated water.

Kempfield Station, Gully Swamp, B., Carcoar Dn.—The new copper lode at Kempfield Station, worked by Lane and party, is reported to promise well. Two parallel lodes occur. Samples assayed, $\frac{146}{98}$, yielded from 28 to 27 per cent. of copper.

Kiandra District, T. & A., Kiandra Dn. (see Lobb's Hole and Talbingo Mines).—At the 15-Mile, Tumut River, Geological-Surveyor Young, in $\frac{1880}{\text{p. }258}$, recorded the occurrence of small veins of copper pyrites in the slates of this neighbourhood, similar to those at Lobb's Hole, but smaller.

Kooningbery Mountains, A., Milparinka Dn., near Packsaddle and Wonaminta.—The Warden, under date 29th July, 1898, states that a mineral prospecting protection area was pegged out for copper in this locality. The prospects were fair, but no developmental work had been done on which to base an opinion of the deposit.

Samples, numbered $\frac{3372 \text{ to } 3374}{98 \qquad 98}$, yielded 25 to 40·82 per cent. of copper. They consisted of red oxide and green carbonate.

Lake George Copper Mines, S., Captain's Flat Dn.—Situated twenty-five miles south of Bungendore, on the Cooma railway line. Elevation about 2,700 feet above sea-level. District well-wooded, with good rainfall.

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* Papers rel. Discov. Gold, vol. i, p. 379.

Mr. J. E. Wright, late of Currowoodgin, near Bombala, about 1874, when engaged on Foxlow Station, near Captain's Flat, first noticed copper ores in the vicinity, but mining did not start until $\frac{1882}{p.\ 24}$, when the discovery of a promising copper lode was announced by the Under Secretary for Mines.

In $\frac{1884}{p.\ 82}$ Warden Woore reported that 2,380 tons of gossan ore had been crushed for 360 oz. of gold (about 3 dwt. per ton). Another parcel of 800 tons yielded 6 dwt. per ton. He further stated that "the character of the reef is an auriferous gossan, overlying a large copper lode of low percentage."

In 1885, blast-furnace treatment superseded the battery, and the two furnaces erected were run intermittently until 1889, when three additional and a 20-head stamper battery and Huntingdon Mill were added to the plant.

In 1890, heap roasting of the sulphides was in operation at the Koh-i-noor Mine, whilst at the Commodore a revolving calciner was erected for the fines.

In 1894, the two mining companies—Koh-i-noor and Commodore-Vanderbilt—were amalgamated under the name of the Lake George United Mining and Smelting Company.

The present Company—Lake George Mines, Limited—came into existence in August, 1896, when English capital was introduced.

In 1897, Messrs. Jaquet and Watt, Geological Surveyors, made a geological examination of the deposits, and from their joint report the following extracts are taken:—

"The dominant formations at Captain's Flat are Silurian slates, breccias, &c., which have a meridional strike, and for the most part nearly vertical dip. Upon the western side of the township flat there is a slight western dip, and at the Vanderbilt Mine, which is situated upon the eastern side of the flat, we found an eastern dip; so an anticline would seem to have stretched across the flat at one time, and the Vanderbilt lode upon one hand and the Koh-i-noor and Commodore lode on the other would seem to be on the same geological horizon.

"The lodes, wherever observed by us, are closely conformable with the bedding planes of the country rock. . . . Portions of the lode exhibit a perfect bedded structure, and without doubt represent country rock, which has been slowly replaced by ore *in situ*. In many places no distinct walls occur, and compact ore may be seen, passing by insensible gradations into country rock slightly impregnated with iron pyrites.

"The Commodore shaft—now called Keating's section—is distant 3,300 feet from the Koh-i-noor shaft—now Elliott's section—and between the two there is 1,500 feet of unproved ground. The lode in Elliott's section to the 400-feet level varies from 22 to 30 feet in thickness. In Keating's section it reached a thickness of 40 feet.

"The unaltered sulphide ore consists essentially of a compact, fine-grained mixture of iron pyrites, galena, and zinc blende, with a small quantity of copper pyrites, and a quartzose aluminous gangue. Upon the footwall side of the pyrites lode in Elliott's section, a considerable quantity of barytes is in places associated with the ore. Between the unaltered primary ore and the gossan which caps the lode, there is present a zone of partially oxidised and enriched sulphides, which differ noticeably from those below in containing black oxide of copper (tenorite), and in being on the whole slightly more friable. The upper portions of the gossan have been almost entirely robbed of their copper, lead, and zinc contents by percolating waters, and the enrichment in copper of the unaltered sulphides is probably due to a portion of the metal having been redeposited as black oxide below."

Captain's Flat, with Lake George Copper Mines and Smelting Works.

The chemical composition of an average sample of the ore from the various exposed faces in the great pyrites lode at the 400 feet level in Elliott's section, taken by Messrs. Jaquet and Watt, is revealed in the following analysis by Mr. H. P. White, F.C.S., Assistant Analyst to the Mines Department, published in the Annual Report of the Department for 1897, p. 21 :—

Moisture at 100° C.	0·10
Combined water	0·65
Insol. in acids (gangue)	23·70*
Metallic iron	17·75
,, zinc	14·50
,, lead	8·04
,, copper	1·11
Sulphate of lead ($PbSO_4$)	0·32
Alumina (Al_2O_3)	1·38
Lime (CaO)	0·40
Magnesia (MgO)	0·65
Sulphur trioxide (SO_3)	0·25
Carbonic acid (CO_2)	2·08
Phosphoric acid (P_2O_5)	0·57
Sulphur (S)	27·97
Oxygen and undetermined	0·53
	100·00

*NOTE.—91·35 per cent. of the gangue consists of silica, the remainder containing alumina, magnesia, and alkalies. The silver contents averaged 2 oz. 8 dwt. 14 grs., and the gold 1 dwt. 12 grs. per ton.

The new plant consists of three water-jacket furnaces of a daily capacity of about 180 tons, and a smaller furnace previously used for concentrating the matte from the above, but since converted into a reducing furnace. Pyritic smelting has been adopted after some initial difficulties. In the furnace charge, about 5 per cent. each of flux and fuel only is required.

The following return of the output of Captain's Flat Mines is compiled from the Annual Reports of the Department of Mines and Agriculture :—

Mine.	Year.	Tons of ore.	Silver.	Per ton.	Gold.	Per ton.	Lead	Per cent.	Copper.	Per cent.
			oz.	oz.	oz.	dwt.	tons		tons	
Koh-i-noor...	1887	2,106	45,705	21·3	377	3·5	125	5·9	21	1
,, ...	1888	Value of product, £6,880—No particulars given.								
,, ...	1889	4,732	54,511	11·5	660	2·8	215	4·5	70	1·5
Commodore-Vanderbilt ...	1890	3,986	33,857	9·0	602	3·0	80	2·0	...*	...
Koh-i-noor	1890	4,860	......	...	823	3·0	(Smelting returns not given)			
Commodore-Vanderbilt ...	1891	5,657	(Smelting returns not given).							
Lake George S. & G. M. Co. (late Commodore-Vanderbilt).	1892	7,322	8,824	1·2	156	0·4	...	...	671	9
New Koh-i-noor	1892	11,900	83,050	7·0	783	1·3	...	...	556	5
Lake George S. & G.M. Co.	1893	7,710	60,000	7·8	...	...	...	...	238	3
New Koh-i-noor	1893	4,264	58,002	13·6	784	3·7	...	...	137	3·2
,, ...	1894	2,247	17,797	8·0	320	2·8	...	...	94	4·0
,, (gossan).	1894	3,946	......	...	391	2·0	...	...	...	...†
Lake George United M. & S. Co.	1894	2,871	14,667	5·0	106	0·7	...	...	55	2
,, ,, ...	1895	18,563	137,951	7·0	2,164	2·3	64	0·3	350	1·9
,, ,, ...	1896	12,783	69,600	5·4	1,251	1·9	36	0·2	205	1·6

* Gossan. † Battery.

OUTPUT of the Lake George Mines (Limited), Captain's Flat; supplied by Mr. R. N. Kirk, Sydney Agent of the Lake George Mines (Limited).

Date.	Ore smelted.	Matte produced.	Gold in Matte.	Silver in Matte.	Copper in Matte.	Gold per ton of Ore.	Silver per ton of Ore.	Copper, per cent.	Cost of Production per ton of Ore.	Remarks.
	tons.	tons.	oz.	oz.	tons.	oz.	oz.	per cent.	shillings.	
From commencement of operations to stoppage in September, 1898.	79,010·4	2,673·62	5,158·12	190,505·08	885·69	0·065	2·411	1·12	...	The gold and silver contents are included in 16·4 tons of bullion, and 6·59 tons of dross, in addition to the matte.
From recommencement of work on 26th November, to 31st December, 1898.	6,351·5	295·56	575·67	15,954·58	92·60	0·099	2·511	1·457	...	
January, 1899	5,312·56	274·20	452·68	13,761·86	76·86	0·085	2·590	1·446	14·78	Total cost of mining, handling, smelting (inclusive of all fluxes and fuels), and general mine expenses.
February, 1899...	5,420·18	291·18	369·63	14,712·55	86·93	0·068	2·714	1·603	14·65	,, ,, ,,
March, 1899	5,840·44	326·96	466·95	15,844·88	97·74	0·0799	2·713	1·674	15·55	,, ,, ,, (of which 1s. 2d. is development.)
April, 1899	5,494·05	278·48	370·48	14,453·04	82·66	0·0674	2·63	1·545	15·58	,, ,, ,, (of which 1s. 6d. is development.)
May, 1899	*5,339·67	232·81	330·0	11,606·	61·71	0·0618	2·17	1·55	16·	Including total cost of mining; handling, smelting, development, and general expenses at the mine. Development equalled 2s. per ton.

* In addition 7·04 tons of precipitates, containing 83·87 per cent. of copper were produced, valued at £522 16s., at present price of copper. Estimated cost of transport and realisation for the month was 6s. 8d. per ton. The sterling value of the ore at present price of metals is £1 8s. 1d. per ton.

LAKE GEORGE MINES, CAPTAIN'S FLAT.

(Powell's Shaft, Koh-i-noor Mine.)

In March, 1899, the Writer inspected the smelting plant and the working levels of the mine for the purpose of recording the latest developments.

The financial success of recent operations had been publicly attributed to free use of accumulated stocks of ore, fuel, and fluxes charged to former accounts, also to robbing the richer portions of the lode.

A visit to Captain's Flat is sufficient to dispel the above illusions. Fuel and fluxes are constantly arriving at the smelters, and ore from all levels is being continuously delivered from the mine.

The rate of winning (by contract) is too rapid and economical, and the output too great (nearly 2,000 tons per week) to allow of "picking." Stoping is being carried on at the 150, 200, 300, 400, 500, and 600 feet levels in the Koh-i-noor section. Certainly a higher-grade copper ore occurs at 150 feet, and a richer, but very refractory, zinciferous silver ore on the east wall of the lode at all levels. The output from these portions of the lode are naturally delivered separately at the ore bins, and judicious blending takes place in charging.

The whole operations of Lake George Mines are, perforce, run on such extremely fine lines, owing to the natural poverty of the lode, that no recoverable element of value can be disregarded. Hence, robbing the mine of an undue proportion of the richer copper-bearing ore would tend to the exclusion of the richer silver ore, and *vice versa*. The latter, again, is so refractory, on account of the associated zinc and lead sulphides, as to prohibit profitable separate treatment.

It is impossible for anyone to pass through the working levels of the Koh-i-noor and Commodore sections of the Lake George Mines without a feeling of profound regret arising over the poverty of a lode which, for size, solidity, and permanence, is rarely equalled.

It is probably the lowest grade smelting problem ever attacked, the difficulties of which are aggravated by the refractory character of the ores. Too much credit cannot be given to those who have skilfully turned it to profitable account, and in doing so established a record for treatment and economy. Though the maintenance of successful working must to a large extent be dependent upon a favourable copper market, yet there is every reason to anticipate discovery of richer ore chutes in the yet unproved portions of the lode between the present points of attack in the oxidised and enriched zones.

The two classes of lodestuff in the Koh-i-noor workings, designated "copper" or "bulk ore" and "silver ore," owe their classification to the relative quantities of copper and silver, which, as will be seen from the following analysis by the Mine Analyst, in either case is exceedingly small:—

	"Bulk Ore."	"Silver Ore."
Silica	21·55	26·48
Iron	22·26	15·19
Zinc	13·26	14·28
Lead	9·70	8·05
Lime	1·60	...
Sulphur	29·50	27·50
Copper	1·25	·94
Gold	·04 oz. per ton.	·06 oz. per ton.
Silver	1·15 ,,	3·03 ,,

The ores are graded into firsts, seconds, and thirds, according to the proportions of zinc in them. Carbonate of lime and a little barytes are also present.

An excellent porous oxide of iron flux is obtained from the gossan outcrop in the Commodore Mine, and copper ore from the Vanderbilt Lode, on tribute.

Special interest naturally attaches to the smelting plant, which, like the mining equipment generally, is admirably planned and housed.

Four furnaces are continuously in operation. The blast (hot) is maintained by four Root's Acme Blowers.

Under the new method of reduction, the matte is brought up to a marketable grade—30 to 35 per cent copper—in one operation, thus avoiding the previous extra cost of concentration in attaining this grade.

The composition of a recent consignment can be judged from the following partial analysis, the gold and silver contents not being stated:—

Copper	34·01 per cent.	Gold, 1·63 oz. per ton.
Iron	20·85 ,,	Silver, 60·00 ,,
Zinc	9·90 ,,	
Lead	11·75 ,,	
Sulphur	22·00 ,,	

Naturally the proportions of the furnace charges (which are varied to suit the idiosyncrasy of each furnace) are matters of commercial secrecy. The constituents, however, are about 12 cwt. of sulphide ore, with variable quantities of limestone, ironstone (from the Commodore Mine), and slag from the fore-hearths and separators. About $3\frac{3}{4}$ to $4\frac{1}{2}$ per cent. of carbonaceous fuel (coke) is added to each charge.

Limestone is procured about three miles from Captain's Flat, alongside the Bungendore Road.

The silica in the ore is just about sufficient for fluxing requirements.

The composition of the slag discharged over the dump is indicated by the following analysis:—

	(i)	(ii)
Silica	34·43 per cent.	37·65 per cent.
Ferric Oxide	35·73 ,,	33·17 ,,
Calcic Oxide	10·86 ,,	10·40 ,,
Zinc	12·16 ,,	14·97 ,,
Copper	·30 ,,	·40 ,,

The discharge from the furnaces is continuous through fore-hearth separators into slag pots.

"Barring down" is performed about every fifth day to remove the crust formed chiefly of oxide of zinc. The operation requires about three hours to complete.

The flue-dust is moulded into bricks, cement being the binding medium used.

Unanderra (South Coast) coke is used in the furnaces.

The plant is lighted by electricity, and telephonic communication is established with all parts of the works, offices, and mine.

At the time of inspection, the old Commodore shaft was being pumped out. The water is highly charged with copper salts, and a primitive attempt was being made to precipitate the copper with scrap iron.

A cyanide plant has recently been erected to treat the auriferous gossan capping the southern extension of the lode, which is estimated to average from $2\frac{1}{2}$ to 3 dwts. of gold per ton.

The Lake George Mines furnish an instructive and valuable object lesson on the possibilities of pyritic smelting.

Larry's Hill Copper Mine, B., Rockley Dn:, Parish Jocelyn, County Westmoreland.—The Larry's Hill lode was opened about 1895, under the name of the Phœnix. A shaft was sunk 90 feet, and several parcels of dressed ore were sent to Lloyd's Smelting Works, Lithgow. Later, about 150 tons were forwarded to Lithgow, and there reduced to matte in a small furnace, by one of the parties interested, in which state it was shipped to London. The quantity and grade are unknown, but the transaction was financially unsuccessful.

LAKE GEORGE MINES.

TRANSVERSE SECTION.

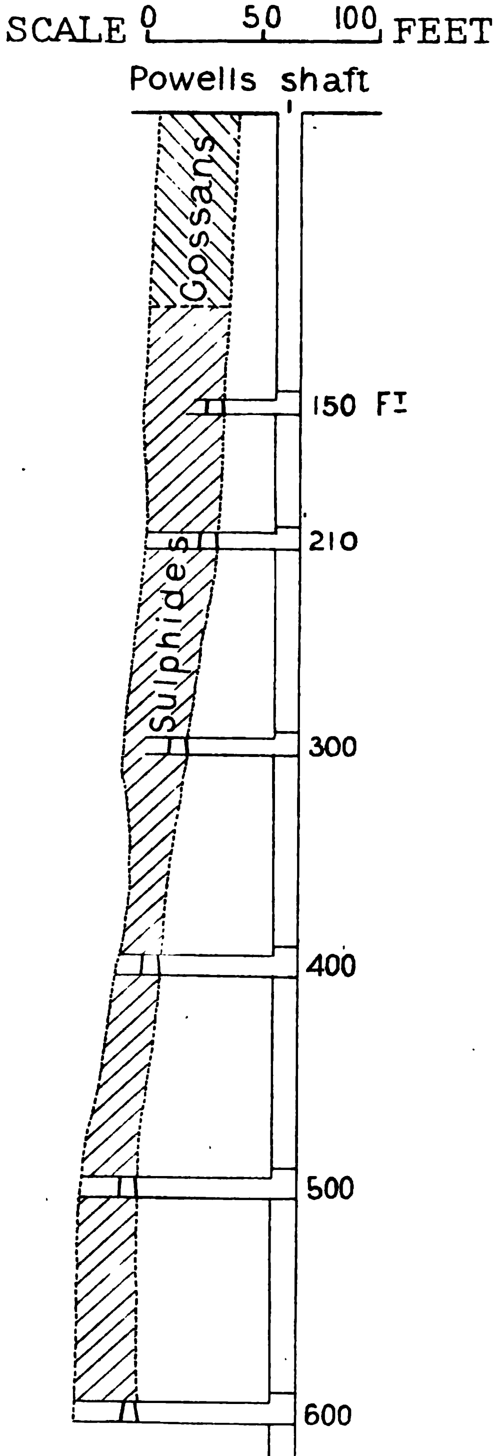

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Photo-lithographed by
W. A. Gullick, Government Printer,

The present owners took possession about eighteen months ago, and began a new shaft about 40 feet north from the first. Later they received aid from the Prospecting Vote to continue to the 150-feet level. At the date of inspection, 14th November, 1898, a depth of 100 feet had been reached and a level driven 30 feet south. At the 50-feet level the shafts are connected.

The geological formations are quartz porphyry passing on the west, through much crushed schistose porphyry, into talcose schist in which the lode occurs striking nearly north and south. Its thickness varies from 1 ft. 6 in. to 2 ft. 6 in..

The oxidised zone extends to a depth of 50 feet, at which level the sulphides appear. The oxidised ores consist of kindly and siliceous gossans with carbonates of copper and lead, thin streaks of grey sulphide, and a little barytes.

The composition of this class of ore may be judged from the following partial analysis:—

No. $\frac{422}{99}$, gossan ores from above 50-feet level.

Copper	6·74	per cent.
Lead	12·10	,,
Zinc	4·58	,,
Iron	23·78	,,
Silica	22·89	,,

Silver, 4 oz. 12 dwt. 13 grs. per ton.
Gold, a trace (under 10 grs. per ton.)

The composition of the sulphides is illustrated in the following table of partial analyses, selected to represent the highest and lowest grades, and an average of the two, the grade being determined by the amounts of copper and zinc present:—

Assay Nos.	No. 495, "Highest Grade."	No. 494, "Lowest Grade."	No. 493, "Average."	Average of 494 and 495.	"Mixed Ores"* from the Rammelsberg, Germany (for comparison).
	per cent.	per cent.	per cent.	per cent.	
Copper	8·45	5·80	6·54	7·12	4·78
Zinc	14·96	30·73	16·49	22·84	21·25
Lead	3·86	7·37	4·76	5·61	8·84
Iron	22·92	12·06	17·79	17·49	12·55
Silica	16·57	10·95	21·12	13·76	19·19
		Per ton. oz. dwt. grs.	Per ton. oz. dwt. grs.		(residue probably silica.)
Silver	Trace.	5 19 18	10 5 19	....	....
Gold	Trace.	Trace.	Trace.	....	....
Sulphur	....	....	....	....	24·11

* Note.—This class of ore (closely approaching the Larry's Hill ore) is subject to special treatment at Oker, on account of the high percentages of zinc and lead. Several special operations are necessary for recovery of the economic metals. The composition of the ore is iron and copper pyrites, zinc blende, galena, barytes, &c. (C. Schnabel, Handbook der Metallhüttenkunde. Translated by H. Louis. Vol. I, pp. 155–6.)

These analyses reveal a refractory smelting mixture, owing to the high percentages of zinc and lead. Repeated heap-roasting with carbonaceous fuel would render this class of ore more amenable to furnace treatment, by eliminating a portion of the zinc and lead contents, but judicious blending with less refractory ores would be most advisable.

Five tons of the better grade of this class of ore were recently treated at the Cobar Syndicate Smelting Works, Lithgow, for a return of 7 per cent. of copper.

Leadville, M., Cobbora Dn. (*See* Mount Stewart Mine).—About seven miles north of Leadville, in Parish Bullinda, County Lincoln. Mr. Alex. Mason is engaged prospecting a copper lode in a 40-acre lease held by him. The Warden reports that the indications are good, but work has not progressed sufficiently to enable an opinion to be formed of the value of the lode.

The Mining Registrar reported in 1898, that nine miles north-west of Leadville, on Davis' Conditional Lease, a shaft was sunk to about 60 feet on a copper lode, which, at 60 feet, was reported to be 2 ft. 6 in. thick. Six tons of ore sent to the Dapto Smelting Works yielded 6½ per cent. of copper. Work abandoned.

Little Copper Hill, L., Molong Dn.—Two miles north of Molong, on the Wellington Road.—Mr. W. Anderson, Geological Surveyor $\frac{1888}{\text{p. 183}}$, reported an outcrop of gossany iron ore, associated with limestone, at Little Copper Hill. It was opened up some forty years previously for copper, but did not prove sufficiently rich to pay for working. Silver is present in the gossan, but the percentage has not been ascertained.

Little Fullback Copper Mine, B., Rockley Dn.—About three-quarters of a mile north-east of Essington Copper Mine. Mr. J. Reed, Manager of Apsley Mine, states that this mine was opened to a depth of 180 feet, and driven 30 feet at the 60-feet level, strike north and south. Ore of good quality was extracted, and sent to Newcastle, during these early workings. Rich sulphides, 9 inches to 18 inches thick, reported to be in bottom of shaft.

The Big Fullback Mine adjoined the Essington on the north, on the opposite bank of Native-dog Creek. Several shafts were sunk from 40 to 60 feet, and an adit driven, but no ore of any consequence was obtained.

Lobb's Hole Copper Mine, T. & A., Kiandra Dn.—On Yarrangobilly Creek, about four miles above its junction with the Tumut River, in slate. The Rev. W. B. Clarke, in his "Southern Gold-fields," 1860, p. 108, states that on the "western flanks of the Munniong [Snowy.—J.E.C.] Range, and in the mountainous regions of Jagungal or Big Bogong and Kiandra, ores of copper abound, sulphurets and carbonates of that metal promising a profitable field of labour and enterprise. Such have been long known to exist in the great breaks of the Tumut, near Lobb's Hole."

Mining probably began at Lobb's Hole about 1874, for in that year the following parcels of ore from the deposit were treated at the English and Australian Copper Smelting Co.'s Works at Waratah:—

5 tons	16 cwt. ;	yield,	26¼	per cent.	of copper.
8 ,,	10 ,,	,,	26½	,,	,,
2 ,,	10 ,,	,,	26½	,,	,,

In 1892, aid was granted to Weselmann and Party to continue sinking on this lode to 160 feet, but they abandoned it after the 80-feet level was reached. Afterwards, the pumping plant was removed to Storey's Reef, Paddy's River, near Tumbarumba. Recently some members of the previous party re-pegged the ground, and, subsequently, it was examined by Mr. E. C. Whittell, Geological Assistant, who reported the lode to be 3 inches, with occasional bunches 12 inches thick, as proved by several shafts for about 1,130 feet horizontal and 30 to 40 feet in depth. This mine is now again being worked, the ore being sent to Dapto, *via* Tumut and Gundagai.

Locksley, B., Bathurst Dn.—About one mile north of the Locksley Railway Station, on the Great Western Railway Line. Opened about 1888. Reopened in 1898. Shaft 80 feet deep. Lode reported to have cut out. Walls well defined.

Louther, B., Oberon Dn., near Mount Victoria.—Copper and silver ore was discovered hereabouts in 1897, which yielded ($\frac{4171}{97}$) 39·9 per cent. of copper, and 15 oz. 5 dwt. 23 grs. of silver per ton; a further sample ($\frac{1442}{98}$) yielded 32·24 per cent. of copper and 20 oz. 18 dwt. 21 grs. of silver per ton; but, unfortunately, a workable deposit could not be found. Samples from Garbenang Road, Louther, which is probably identical with the copper locality $\frac{2700}{98}$, $\frac{2701}{98}$, and $\frac{2838}{98}$, yielded from 19 to 23·5 per cent. of copper, and 5 to 6 oz. of silver per ton.

Lue, M., Mudgee Dn.—Mr. Warden Wilkinson reports that good indications of copper lodes occur near Lue, where a little prospecting has been done, but nothing systematic in the way of proving. Assays $\frac{2170}{97}$ and $\frac{1404}{97}$ yielded 23 per cent. of copper and 6 oz. to 9 oz. of silver per ton.

McAlpine Copper Mine, T. & A., Tumut Dn., on Kiley's property.—This lode was originally opened to a depth of 90 feet in serpentine. Recently it was reopened under the supervision of Mr. J. J. Kelly, who states that after continuing sinking another 20 feet, and taking out 38 tons of copper ore, the lode cut out. The ore extracted, 9 tons 17 cwt. 3 qrs., treated at the Smelting Company of Australia's Works, Dapto, yielded about 10 per cent. of copper.

McGrath's Copper Lode, A., Broken Hill Dn.—Mr. W. H. J. Slee, Chief Inspector of Mines, $\frac{1888}{\text{p. }126}$, reported that the ore was visible on the surface in a short bunch 20 feet in length. Five tons sent to Adelaide are reported to have yielded 12 per cent. of copper.

Major's Creek, S., Braidwood Dn.—Copper ore occurs in Rigby's Reef, about one and a half miles north-west of Major's Creek township; but gold is the chief element of value. 2½ cwt. of stone from the 64-feet level, sampled and assayed at the Australian Smelting Company's Works, Dapto, yielded:—

Gold	19 dwt. per ton.
Silver	26 oz. ,,
Copper	14½ per cent.
Antimony	5 ,,

Thirty tons subsequently forwarded yielded only 4 dwt. of gold and 9 oz. of silver per ton, and 3 per cent. of copper. The unoxidised ore consists of iron and copper pyrites and fahlerz.

Manduramah, B., Carcoar Dn.—About four and a half miles north-west of Manduramah and three miles south of Burnt Yards. Mr. J. A. Watt, Geological Surveyor, reports that blue and green carbonates of copper are plentifully scattered through andesitic rock at this site, from the surface down to the depth attained, 27 feet, and that the prospects were favourable. Aid was granted to sink 77 feet and drive 50 feet on the course of the lode. The result of this exploration, however, did not sustain the surface indications. No sign of a lode was visible. The occurrence of copper in the Carcoar andesite and its deceptive indications have been specially alluded to in this work.

May Day Mine, C., Gilgunnia Dn.—In this mine a considerable amount of prospecting has been done for gold, but, like the rest of the field, with little success, the gold being disseminated through slate near the junction of porphyry, but not in sufficiently concentrated form to pay for working. Lead carbonate occurs freely in small veins and vughs, and is usually rich in silver. The metalliferous belt at the May Day is upwards of 100 feet in width. It strikes about north-east, with a south-easterly underlay. At 85 feet in the north-east shaft, copper carbonate and red oxide made their appearance, and have continued to present level—102 feet. These ores occur in a width of about 3 feet, and at 102 feet are just dipping out of the shaft. The ore is of good quality, but further testing is necessary to determine its quantity. A sample of azurite (blue carbonate of copper) and carbonate of lead assayed $\frac{2340}{98}$ yielded copper 7·84 per cent., lead 5·94 per cent., and silver 16 oz. 19 dwt. 17 grs. per ton.

Mayfield Copper Mine, S., Boorowa Dn., Rye Park, about seventeen miles east of Burrowa.—This mine was opened in $\frac{1884}{p.\ 61}$. Fifty tons of ore raised yielded 9 tons of copper, valued at £360. Shaft, 125 feet deep; lode, 2 ft. 6 in. thick. In $\frac{1898}{p.\ 49}$ the mine was being developed; no output recorded. In $\frac{1897}{p.\ 71}$ worked by a party of four; output valued at £1,605. The following parcels of ore were treated at the English and Australian Smelting Works, Waratah:—

Tons.	cwt.		Yield.	Tons.	cwt.		Yield.
13	13	...	12½ per cent. copper.	4	10	...	10½ per cent. copper.
2	10	...	23 ,, ,,	3	18	...	15¾ ,, ,,
5	1	...	9⅝ ,, ,,	10	8	...	15¼ ,, ,,
9	18	...	15½ ,, ,,	5	0	...	32 ,, ,,

Melrose District, L., Condobolin and Bobadah Dns.—Copper ores occur sparingly over a considerable area in this district, but so far none have been proved in workable quantity. Copper was first discovered hereabouts by J. Byrum, about fourteen years ago. The chief feature of interest is the association of the copper ores chiefly with ancient conglomerates, much crushed and indurated. The pebbles consist of quartz, and the cementing argillaceous material has by pressure and shearing assumed a schistose structure. The alternating slates and sandstones are highly ferruginous. In some instances the cleavage planes of the slates are coated with copper carbonate, which, at a lower depth gives place to a film of red oxide of copper.

The following cupriferous outcrops have been more or less prospected in this district:—

Anaconda Mine (which see)—In conglomerate and slate.

Big Ben Mine (which see)—In conglomerate and slate.

Melrose Mine (which see)—In conglomerate and slate.

Mount Susannah, near Melrose Homestead—Conglomerate.

Mount Nobby, in Morris's Conditional Purchase—Conglomerate. Now being worked by the Mount Nobby Copper Mining Syndicate.

Mahgalore, in felsite.—This vein was sunk upon to a depth of 31 feet. The vein stuff consists of ferruginous quartz, partly chalcedonic. Strike N. 70° E., dip S. 20° E. slight. Iron oxide is abundant in the lode. Copper carbonate occurs on faces of joints in the felsite near the surface, but at a greater depth, the grade is reported as improving. At 50 feet copper ore in gossan 3 feet thick was met and continued to 75 feet, the shaft being continued to 100 feet. A sample of sulphide ore recently assayed, $\frac{4310}{98}$, yielded 44 per cent. of copper.

Melrose Copper and Silver Mine, L., Condobolin Dn., about three-quarters of a mile west of the "Melrose Hotel."—Discovered and opened by J. Byrum, who was aided to sink from the Prospecting Vote. The mine is situated on a rugged hill about half a mile north of the Big Ben Mine. Ferruginous slate crops out in cliff-like masses on its summit, having a north and south cleavage. In one spot the slate is stained by copper carbonates, forming films on the cleavage planes. A few feet to the west a flat cross joint carries some massive carbonate of lead, stained with carbonate of copper. It has been followed some distance on the dip to the north-east. The aided vertical shaft is situated between the two outcrops, and a cross-cut intersects the cupriferous slates at about 100 feet deep. At this level the cleavage planes of the unweathered slates are coated with films of red oxide, which accounts for the carbonates on the surface. Prospecting operations not having revealed a payable ore deposit, work has been discontinued for some time.

Milburn Creek Copper Mine, B., Trunkey Dn., parish Dunleary, county Bathurst.—This mine has had an eventful history, involving both legal and political issues. Briefly stated, the cause of trouble was a disputed title, as set forth in a petition presented to Parliament, in the 1873–4 Session, on behalf of one Robert Martin (Vol. IV, Parliamentary Proceedings, p. 857). Therein it is stated that petitioner selected a mineral conditional purchase at Milburn Creek, on or about the 15th September, 1872; entered into possession and commenced work. At time of survey his right was disputed by Baker and party, to whom subsequently a lease was issued by the Department of Lands prior to the formation of the Department of Mines. Baker and party erected three reverberatory furnaces about one mile from the mine, and extracted a considerable amount of copper. Their title to the mine was, however, upset by the Supreme Court. Compensation was granted in 1879 to Baker and party for loss of lease granted to them. The distribution of the sum voted by Parliament to the Milburn Creek Copper Mining Company (which was floated by Baker and party after the lease was secured by them) caused so much dissatisfaction and adverse comment amongst certain shareholders, which was intensified by the explanation offered, that Parliamentary notice and action was invoked, followed by the appointment of a Royal Commission of Inquiry, the results of which are matters of political history. Naturally, these proceedings cast a shadow on the mine as an investment, notwithstanding that the inquiry revealed the existence of proved bodies of sulphide ores of good grade.

Attention is now being turned to it after a lapse of twenty years, and the old workings are shortly to be unwatered preliminary to reopening.

Probably the first ore raised from the mine is represented by the following parcels sent to the Newcastle Smelting Works in June, 1873:—

	Yield.
2 tons 13 cwt.	18¼ per cent. copper.
2 " 4 "	9 " "
2 " 7 "	25¼ " "
4 " 11 "	11⅛ " "
3 " 13 "	22¾ " "
3 " 17 "	19¼ " "
2 " 2 "	23 " "

The Milburn Creek Copper Mining Company consisted of 72,000 shares of £1. Soon after its formation a furnace was erected at a cost of £480, fireclay and brick being obtained from Bowenfels for the purpose.

At the Second Annual Meeting of Directors for the year ending 30th June, 1876, 1445½ tons of ore were reported to have been raised, of which 500 tons of 13 per cent. ore were smelted for 67 tons of copper; the balance of the ore—945½ tons—were sold to the Esk Smelting Company, Bowenfels, for £4,001, averaging 11¼ per cent. Forty men and boys were then employed.

An arrangement was made during the year with the Esk Smelting Company to rent the Milburn Creek Company's furnace, and to erect two additional furnaces, and to purchase all the latter Company's copper ore on an agreed scale of prices.

A portion of the lower level of the mine was let on tribute (in yellow ore). A lode of black ore at the south end of the workings was averaging 16 to 21 per cent. of copper.

The Directors report at the Third Annual Meeting ending June 30, 1877, states that the mine was worked up to within a few days of the above date, when it was suspended pending the Supreme Court decision as to the validity of the lease.

During the year ore to the value of £6,697 was sold to the Esk Company, and 200 tons were at grass.

The following description of the mine and its workings is from the report of the late Under Secretary for Mines, Mr. Harrie Wood (Ann. Rept., Dept. of Mines, 1878, pp. 23-24):—

"The mine is situated on lightly timbered box ranges, composed of altered (Upper Silurian) slates and sandstones, dipping W. 10° S. at about an angle of 70°. About three-quarters of a mile from the mine the slates give place to ternary granite, while in a W.S.W. direction the nearest granite is distant about 1½ mile. It will thus be seen that the copper lodes occur in a belt of altered slates, bounded by granite. The surface indications of the several lodes are characteristic. They appear as quartz veins, containing much gossan (the result of the decomposition of copper and iron pyrites), and a few stains of carbonate of copper.

"At a slight depth the gossan gives place to carbonates and oxide of copper, while below these appear the sulphides, &c.

"The greater part of the work done in the Milburn Creek Mine has been the extraction of the oxidised ores of copper (carbonates and oxides) which necessarily occur nearest the surface; two distinct lodes have been worked, and on these have been sunk no less than eighteen shafts on what are known as the 'north and south lodes'. An adit has been driven from the side of the hill, and reaches a depth of 56 feet below the crown of the range. From this adit nearly up to the surface the carbonates have been removed by stoping.

"From one of the shafts, at a depth of 25 feet below the adit, another adit has been driven northward. Good ore (copper glance, yielding in the company's furnaces 8 to 20 per cent. of copper) has been worked in this level, the lode here being from 4 ft. 6 in. to 5 feet wide. A specimen of this ore was assayed by Mr. Dixon, F.C.S., F.I.C., and yielded 27·9 per cent. copper.

"From this level a winze has been sunk to a depth of 27 feet, and from the bottom a drive has been worked northwards. Very good ore has been obtained here, viz., grey sulphide of copper, which in the company's smelting works yielded 20 per cent. of copper; while Mr. Dixon found in a sample submitted to him 45·9 per cent. The lode in places is as much as 11 feet wide, though somewhat irregular, narrowing occasionally to 5 ft. 6in.

"The south shaft is vertical to a depth of 65 feet from the surface, and at this depth a drive has been put in east and west along the lode. A winze has been sunk 29 feet through yellow sulphide of copper and peacock ore, forming a fine lode, which increases rapidly in width as it descends.

"The south shaft has been continued down on the underlie to a further depth of 140 feet, through the same ore, which at the bottom shows a splendid solid lode 11 ft. 6 in. in width, and without any gangue visible. The lode at this point dips at an angle of 63°. A sample of this ore was assayed by Mr. Dixon and yielded 16·7 per cent. of copper, though in the Company's smelting works it only averaged 9 per cent.

"The water of the mine holds a quantity of sulphate of copper in solution, which, while the shaft is being baled, colours the creek a strong emerald green for a distance of more than a mile from the mine." . . . . .

In reopening the mine the recovery of the copper in solution in the mine water is contemplated, by means of tanks charged with scrap iron, through which the water will pass. The quantity of copper in the Milburn Creek Mine water was found by Mr. W. A. Dixon to be 328·9 grains per gallon, equal to 4·698 lbs. per 100 gallons. This water contained a considerable quantity of sulphate of iron in solution, but no free acid.

In the south shaft the lode was found to improve in solidity and width as it descended, and at a depth of over 200 feet it was fully 11 ft. 6 in. from wall to wall.

In 1877 the mine changed hands under a Supreme Court decision. In $\frac{1878}{p. 63}$ it is stated that operations were continued during the year, and a considerable quantity of regulus was sent to Bowenfells to be refined. The Warden stated that, though badly worked, the mine was reported to be looking well.

In 1888 another law suit was pending. Nothing further appears in the records until $\frac{1888}{p. 69}$ when 14 tons of copper were dispatched, work having been resumed by C. J. Campbell. In 1898 prospecting was being carried on along the line of strike outside the property, and quite recently a movement has been made to reopen the mine.*

Molong Creek, L., Molong Dn.—Mr. S. Stutchbury, in 1851, mentions that he found a green rock "smaragdite," containing pure native copper, about one mile south of Mr. John Smith's house, and 100 yards west of Molong Creek.

In Spring Creek, near its junction with the Bell River, in the Parish of Eurimbla, County Gordon, large pieces of native copper were found some years ago on the surface. A few thin quartz leaders, with calcite showing carbonates and grey sulphide of copper, and assaying 43 per cent. of copper, were sunk upon but gave out at a shallow depth, according to Mr. W. Anderson, Geological Surveyor, $\frac{1888}{p. 183}$.

Monmouth Copper Mine, Gulgandra Creek, Monaro.—In the catalogue of the Sydney Exhibition of 1870, copper ores from this mine are mentioned. Work was at that time being carried on by a party of Victorians, who were sinking a shaft.

Moonta Copper Mine, B., Orange Dn.—(*See* Great Western Copper Mining Company).

Mootwingee Copper Mine, A., Broken Hill Dn. (also referred to as Mannerings).—In $\frac{1889}{p. 182}$, the Mining Registrar reported that four men were employed in this mine. Copper carbonates had been struck at 9 feet, assaying 29 per cent. copper. Sample $\frac{2022}{98}$, from Mootwingee, yielded copper, 41·40 per cent., and 20 oz. of silver per ton.

Mount Boppy Copper Mine (*late New Burra Burra*), C., Cobar Dn.—About four miles southerly from the Mount Boppy Railway Station. This mine is situated at the junction of porphyry and slate. Several shallow shafts and a

* An application to register the Milburn Creek Copper Corporation, Ld., as a limited liability company, in 1,000 shares of £10 each, in Melbourne, was published in the *Australasian* of 26th June, 1899.

deeper main shaft was sunk on the lode; but as the mine was closed at the time of inspection, the underground developments could not be examined. Some very good ore, both carbonate and sulphide, was lying at grass, the matrix being a greasy chloritic slate.

A reverberatory furnace has been erected adjacent to the shaft and a limited amount of ore smelted. 8 tons 15 cwt. of black copper from the reverberatory, treated at the English and Australian Smelting Works, Waratah, yielded 87½ per cent. of copper. In the *Australian Mining Standard* of the 18th November, 1898, the sale of this mine was reported to a Colonial syndicate.

The property consists of a 40-acre lease taken up in 1886. Its official history is briefly that, at 13 feet, carbonate and gray sulphide were struck in the lode which had a thickness of 5 feet, a north and south strike, and a slight western dip, 30 tons raised—picked samples—assaying 38½ per cent. of copper. In $\frac{1887}{p.108}$ very little work was done, the lease being sold to a Cobar syndicate. In $\frac{1888}{p.123}$ mining was suspended owing to scarcity of water; a tank was however being excavated and a furnace erected In $\frac{1889}{p.127}$ a quantity of ore was reduced, but the product was not refined. In 1890, 500 tons of ore were reported at grass, and about 6 tons of copper were produced. In 1891, stoping and smelting ceased, and Government aid was granted to further explore the lode. In 1893 the mine was closed.

In $\frac{1897}{p.93}$, Inspector Milne reported that considerable energy was displayed in prospecting the mine. The main shaft had reached the 200-feet level, and a crosscut driven west 70 feet exposed bunches of sulphides. The shaft was to be continued and a crosscut driven at a lower level. In 1898, however, a compulsory sale of the surface gear put an end to operations.

Mount Bodangara Copper Mine.—(*See* Wellington District.)

Mount Bullen, T. and A., Queanbeyan Dn.—About one mile S.E. of Coyle's Mine, at the junction of the Colter and Paddy's Rivers. Mr. Danvers Power, F.G.S., states that a recent discovery of copper ore was made at Mount Bullen in an amphibolite dyke in felscite and syenite country. The dyke has a width of about 1 chain and can be traced over Mount Bullen to the Colter River, where copper stains are visible. The outcrop consists generally of magnetic iron with stains of copper carbonates. The only proving is to a depth of about 10 feet by a length of 10 feet in copper-stained lodestuff.

Mount Carrington, N.E, Fairfield Dn.—A little copper ore has always been a feature of the auriferous veins and lodes of the Drake District (*see* Drake), and with depth payable copper veins have been opened. Under date July 14th, 1898, Mr. J. P. Curran, Warden's Clerk, Drake, has supplied the following particulars of the present aspect of the copper mining industry in his district:—

"Three distinct copper lodes, striking north and south, occur on the north side of Mount Carrington. The ore at surface is of good quality, but operations so far are too shallow to allow of definite determination as to permanency of lodes. The indications, however, are favourable.

The lode in Mineral Lease 5 of 40 acres, held by J. Staunton and Party, appears well defined and about 3 feet thick. It has been opened in several places for a distance of about 10 chains, disclosing carbonates of good quality near the surface, and native copper and red oxide just beneath.

In 1893 the following parcels were treated at the English and Australian Smelting Works, Waratah:—

		Yield
19 tons	9 cwt.	20 per cent. copper.
7 „	0 „	18 „ „
5 „	5 „	25 „ „
3 „	5 „	21 „ „
12 „	10 „	18½ „ „
5 „	17 „	19 „ „
3 „	16 „	21 „ „

In addition, Mr. Curran reports that a large quantity of this ore was treated by the Adeline Company in 1891 at its local works with very satisfactory results.

A short distance west of Staunton and party's mine, is another parallel lode worked by D. Creed and party in a mineral lease of 20 acres. A shaft had been sunk to 35 feet, at which level a large bunch of red oxide was met. The lode, so far as opened, varies from 9 inches to 3 feet in thickness.

About 12 chains south of Creed and party, and apparently on the same line, Handcock and party are working at a depth of 140 feet on a 6-inch copper vein, composed chiefly of black oxide, assaying from 20 to 40 per cent. of copper. A parcel of 5 tons recently treated at the English and Australian Smelting Works, Waratah, yielded 25 per cent. of copper and 1 oz. gold per ton.

A short distance further west, D. Mickle and party are working the Great American Barber Mine (which see).

In the adjoining block, on the same line, Hawkins and Tubman, at a depth of 40 feet, are working on a small but rich vein of black oxide assaying from 30 to 40 per cent. of copper. Considerable improvement in the width of the vein was manifest at the 60-feet level at a later date, the lode being well defined, the matrix quartz, with about 2 feet of clean ore over 30 per cent. grade.

Still further west, Kay and Peacock have opened a promising copper lode on what is regarded as a new line, and at a depth of 15 feet obtained a quantity of black and yellow ore. Two veins occur in the shaft, 9 and 12 inches thick.

The Adeline Mine, which was originally worked for gold, may now be classed as a copper mine, as copper is the predominant metal. At the 100-feet level the lode for a considerable distance along its course varies from 3 to 5 feet in thickness. 16 tons 10 cwt. treated at the Smelting Company of Australia's Works, Dapto, yielded 1 ton 4 cwt. of copper—equivalent to about 7½ per cent.

Mount Costigan, B., Tuena Dn.—In the Mount Costigan Silver-Lead Mine, copper sulphides made their appearance below water-level, in a refractory combination with sulphides of lead, zinc, and iron, very similar to the ores in the lower levels of the Lewis Ponds and Sunny Corner Silver Mines.

Mount Gipps, A., Broken Hill Dn.—In 1885 samples from twelve miles north-east of Mount Gipps, consisting of carbonate, oxide, and sulphide of copper, yielded by assay 22 to 43 per cent. of copper.

Mount Hope District, C., Mount Hope Dn. (*see* New Mount Hope and Great Central Mines).—At Mount Allen some years since a tunnel on the north-west side was driven some distance in search of copper, but nothing of importance was discovered.

At Coan Peak, on the south-west side, a little copper has been discovered in porphyry. Three shafts were sunk to shallow depths, following a quartz vein. The occurrence is known locally as the Coan Copper Mine, Mineral Lease 33, Parish Coan, County Blaxland, but no workable or defined ore body has been found.

Double Peak—locally known as "Dromedary"—consists of porphyry and slate. On the west side, opposite the village of Mount Allen, a rather extensive outcrop of magnetic iron occurs, in parts highly siliceous. Stains of copper carbonates are visible in solid pieces of the magnetite. A considerable quantity of the latter has been carted to Mount Hope for fluxing purposes. This site was originally opened for gold. In a shaft sunk 50 feet alongside the ironstone, pyrites was met, and in an eastern crosscut copper carbonates; but the latter was not followed, as gold was sought at the time. On the top of the east peak, copper carbonates crop out in a claim held by McGuire and party. A little further south, on the same line, gold was found in ironstone and ferruginous slate, from which various parcels have yielded from 4 dwt. to 17 dwt. of gold per ton. The lode-stuff closely resembles that of Mount Allen Gold Mine. Aid was granted to Hill and party to tunnel into the mountain at a level about 200 feet below the auriferous outcrop on the slope. At 340 feet the lodestuff was cut, consisting of soft slate with iron and copper pyrites, the latter, however, not in payable quantity. A drive along its course is being extended in search of more concentrated ore bodies.

The copper indications of this mountain deserve more attention.

Mount Lindsay, C. & R., Casino Dn.—Carbonate of copper occurs on the slopes of Mount Lindsay, near the Queensland border, according to the Rev. W. B. Clarke, in a report dated June 24th, 1853. (*Papers rel. Gold Discovery*, vol. iii, p. 12.)

Mount McDonald, B., Trunkey Dn.—About half a mile north of Mount McDonald and the same distance south of Milburn Creek Copper Mine, in the Parish of Dunleary, County of Bathurst.

Mr. D. Milne, Inspector of Mines, $\frac{2410}{1898}$, states that the country consists of slate with bunches of quartz, gossan, and blue and green carbonates; strike north and south. Apparently a continuation of the Milburn Creek Lode. The only proving at the time of inspection was several shallow openings along the out-crop. Aid granted to sink 60 feet, and to drive 80 feet on the course of the lode. A sample from the outcrop, $\frac{1408}{98}$, consisting of ferruginous blue and green carbonates, yielded 40·1 per cent. of copper, and 8 oz. 18 dwt. 14 grs. of silver per ton.

On the southern strike of the Milburn Creek Lode, shafts were sunk some eighteen years ago to depths of about 70 feet, and some rich ore is reported to have been raised.

Mr. A. McCourt, of Mount McDonald, is prospecting the locality known as Gordon's Mine.

Mount Pleasant Copper Mine, P. & U., Nundle Dn., Dungowan, about twenty-eight miles from Tamworth, County Parry.—The late Government Geologist—Mr. C. S. Wilkinson—in $\frac{1886}{p.135}$, reported that "at Mount Pleasant, on Dungowan Creek, Mr. T. Hole, has had a shaft 50 feet deep sunk in prospecting for a copper lode, where the altered red jasperoid slates are traversed by a small irregular vein a few inches thick of gossan, quartz, and serpentinous clay containing carbonates of copper. It is evidently a decomposed vein of copper and iron pyrites, and of no value as a copper lode; but in one specimen I detected free gold, and I would advise further prospecting to ascertain if gold does not exist in payable quantity. Jasperoid rocks appear at the surface for about 10 chains in a north-easterly and south-westerly direction, and in places are stained with carbonates of copper."

Three mines are known in this locality, the Dungowan, the Kurrajong, and the Mount Pleasant.

In 1886, several tons of ore from the Mount Pleasant Mine were tested and found auriferous but not payable.

Mr. Warden Jones, writing under date 19th July, 1898, stated that the mine occurs on a conditional lease, and that a permit was granted to G. Hyde in 1897, but no work was done under this authority.

Mount Ragan, B., Orange Dn.—At Mount Ragan, five miles south of Lewis Ponds, and half a mile east of the old Britannia Copper Mine, aid was granted (Pros. Papers 99–1,305) to sink in a copper lode in slate country, which Mr. H. Hooke, Inspector of Mines, regarded as offering fair prospects.

Mount Stewart Silver-Lead Mine, M., Cobbora Dn.—In the lower sulphide zone of the Mount Stewart Mine, the owner, Mr. C. L. Garland, states that a little copper pyrites is making. The outcrop of the lode consisted of very kindly porous gossan with carbonate of lead; the latter, however, ended abrubtly at the water-level, where friable, finely crystalline pyrite formed the lode, becoming more massive with depth.

About half a mile south of the main workings on the same north and south strike, three gossan outcrops occur about 150 and 200 feet apart. In the most northern, a shaft, partly vertical and partly inclined on the underlay, at 130 feet encountered siliceous sulphides, assaying 6 per cent. of copper, which were driven on 40 feet. In the second outcrop, 150 feet south, a main shaft is being sunk to a depth of 250 feet.

At 125 feet, kaolin and gossan were struck, and a drive extended along the gossan for 80 feet, the latter assaying up to 15 oz. of silver per ton.

At 200 feet the shaft passed into the country as the lodestuff dipped to the north.

In the third and most southern outcrop, 200 feet from the second, a shaft has been sunk 100 feet in gossan carrying silver.

It is the intention of the owner to continue the main shaft to 250 feet, and then drive northerly to cut the ore body between the first and second shafts to prove the value of the copper ore. If a permanent body is available, it could be advantageously worked with the already proved abundant pyrites and silver-bearing gossans.

Mount Susannah Copper Mine, C., Bobadah Dn.—About one mile from Melrose homestead.

A cupriferous outcrop in crushed conglomerate close to intrusive porphyry was opened here about fourteen years ago by J. Byrum. Shafts sunk 30 and 40 feet revealed carbonate of copper impregnating the country for about 6 or 7 feet in width along a north and south strike, but no payable ore bodies were exposed. Recently, aid has been granted to continue one of the shafts to 100 feet level, and to drive along the lode.

Mount Trooper, T. & A., Delegate Dn.—A little copper ore occurs in the Snowy River granite, on a low spur opposite Mount Trooper, on the east bank of Sandy Creek, about two miles from the Victorian border. Copper ore in minute quantities was also detected by the writer on the border about half a mile east of the Snowy River. At Sandy Creek a little prospecting was done, but the indications were not favourable for the existence of ore in quantity. A picked sample of the best grade yielded 7·03 per cent. of copper, and silver at the rate of 17 dwt. 9 grs. per ton.

Mullion Range, B., Orange Dn.—Mr. S. Stutchbury, Geological Surveyor, in April, 1852, mentions copper having been picked up on Mullion Range, on the property of Mrs. F. Lord.

Mulloon Copper Mine, S., Braidwood Dn., thirty miles north-west of Braidwood, and ten miles south-west of Boro.—Mr. James McDonald, of Braidwood, has kindly supplied the following particulars of the above mine, which is situated on the property of Messrs. Scott:—"This mine was worked some twenty-five years ago, and a furnace was erected for smelting purposes, but prematurely, as little prospecting had been done. The shaft was down 100 feet. The ore consisted of grey sulphide, assaying very high, but occurring only in bunches. Both gold and silver were associated with the copper. By the time the above work had been completed the capital was understood to be exhausted, and the enterprise was abandoned." Mr. McDonald adds that there is an outcrop, with carbonate ore, traceable for a considerable distance, which might be worth trying at the present time. In the *Australian Mining Standard* of the 12th January, 1899, it is reported that a local company has been formed to reopen the mine.

A trial parcel of copper ore from Boro, treated by the English and Australian Smelting Co. at Newcastle in 1873, doubtless came from this mine, viz., 1 ton 11 cwt.; yield, $12\frac{7}{8}$ per cent. of copper.

A recent inspection by the Writer disclosed a considerable amount of work, but all very close together. The furnace, for some unaccountable reason, was erected some miles from the mine. The timbering of the shafts has all been destroyed by fire, so that inspection is not now possible. Limestone is adjacent to the mine. (*See* Boro Mine.)

Opposite the Mulloon Mine, on the south side of Mulloon Creek, McLaughlin and Party are working the adjoining property, which was opened about twenty-seven years ago at the same time as the Mulloon. Taken up by the present proprietors in December, 1898; country, slate; lode-strike, east and west but wavy, following bedding of country. In an open cut close to the creek a wide body of copper ore is exposed without defined walls. A little good ore is visible in the old stopes. No particulars are available of the results of the early workings.

Mummell Copper Mine, S., Goulburn Dn.—In the *Australian Mining Standard*, December 17th, 1896, it was reported that a lode had been struck in this mine at a depth of 100 feet, having a thickness of 1 foot, according to a previous issue. Assays $\frac{199 \text{ and } 200}{80}$ from this locality yielded from 28 to 35 per cent. of copper, the ore being glance.

Under date of December 8th, 1898, Mr. J. B. Jaquet writes that the Mummell Copper Mine occurs in R. Lamb's property, about ten miles west of Goulburn, in slate country. The lode, from 2 to 13 feet wide, dips west at an angle of about 45°. The lode material consists of country rock, silicified and otherwise altered, with veins and nests of copper and iron pyrites, with a little galena and blende. The ore, on the whole, is very siliceous. Some rich carbonate ore was obtained near the surface. About 70 tons have been sent away to various smelting works for treatment, yielding, according to Mr. Lamb, about 17 per cent. of copper. The lode has been proved to a depth of 70 feet by a shaft, and short drives have been driven along its course at that level.

New Mount Hope Copper Mine.

NEW MOUNT HOPE COPPER SMELTING WORKS.

A shaft to cut the lode on the underlay has been sunk 100 feet, at a distance of about 60 yards from the outcrop, naturally without cutting the lode at that level.

Murrumbidgee River Basin.—The Rev. W. B. Clarke, in a report* dated June 1st, 1852 writes as follows of portion of this area:—

"The whole basin of the Murrumbidgee, from near Bullanamang to the junction of the Queanbeyan River, and even as far as the junction of the Yass and Goodradigbee Rivers (as, for instance, at Good Hope), exhibit not only metalliferous formations, but in some places lodes of lead, copper, and iron; and there can be no question that in some of these localities metallurgical operations may be profitably conducted. The association of abundance of limestone with these deposits is quite in accordance with similar associations in the mining countries of the European and American continents. The quartz porphyry, which occupies so large an area in the Murrumbidgee basin, is in Europe one of the most important and prolific sources of mineral wealth.

"Judging from what I have seen of the ores and vein-stuff of the copper lodes of Pudman Creek, on the Burrowa branch of the Lachlan, I presume that the Murrumbidgee deposits are continuous to the north, probably branching at intervals along the 149th meridian, to a junction with the copper and lead districts of the Belubula and Macquarie.

"A further confirmation of the metalliferous nature of the region along the 149th meridian is shown by the lodes of copper and lead about Quedong and the traces of similar ores on the McLaughlin.

"Near the junction of the Queanbeyan and Murrumbidgee Rivers the copper is found occasionally in the native state—*i.e.*, pure—in flakes adhering to the laminæ of the granite rock, which is traversed by the lodes. Near Yarralumla I saw somewhat similar examples."

Murrumbidgee Copper Mine, L., Boorowa Dn., mineral lease, 40 acres, Parish of Birrama, County Harden.—Mr. W. Anderson, who examined this mine in connection with the Prospecting Vote ($\frac{8124}{1892}$) reported that an underlay shaft had been sunk 125 feet in a well-defined lode in granite, and several levels driven. The lodestuff was reported to consist chiefly of copper pyrites; but, judging from samples shown the Writer, the bulk of it was magnetic iron oxide. Aid was granted to continue prospecting, but without satisfactory results.

Nangar Range, L., Cudal Dn.—Copper ore in small quantity, so far as proved, occurs in two places on the north side of the Nangar Range, about two miles southerly from the "Murga Hotel." In Clayton's gold lease, at a depth of 80 feet, in ferruginous quartzite, a small patch of red oxide of copper was cut, but it appeared entirely isolated, as further search failed to reveal any other indications of a copper deposit. This occurrence is close to intrusive quartz felsite. About half a mile distant from this site, and close under the mural cliffs of the range, a little carbonate and sulphide of copper, associated with quartz and talcose material, has been opened for a few feet, and is still being tested. The Nangar Range consists of massive conglomerates and sandstones probably of Devonian age.

Neila Creek, L., Cowra Dn.—On Conditional Purchase 78/75, Parish Morongla, County Forbes, about ten miles south of Cowra, a shaft has been sunk 73 feet in a strong gossan outcrop, in which a little copper is visible. A crosscut has been driven 108 feet. Aid was granted to continue sinking.

**Southern Gold-fields*, pp. 236, 237.

Nelson Copper Mine.—(*See* Great Western Copper Company.)

New Mount Hope Copper Mine, C., Mount Hope Dn.—Discovered by a miner named McDowell about 1878. In 1880 it was visited by Mr. L. H. G. Young, accompanied by the Writer. A shaft had been sunk, but the mine was practically abandoned at that date. Mr. Young reported ($\frac{1880}{p.261}$):—"The copper mines at Mount Hope may be divided into three outcrops, more or less in a line with each other, namely, Mount Hope, South Mount Hope, and McDowell's. Of these, Mount Hope is in iron sandstones, having a strike N. 7° E. and dipping 80° to the west, while the other two are in a porphyry formation. The copper at Mount Hope appears to occur in a defined lode, composed largely of quartz, argillaceous matter, and earthy blue and green carbonates of copper, with occasional masses of red and brown iron ore, and also some earthy red oxide of copper and grey sulphide. The main lode is 24 feet wide on the surface, and there are two parallel outcrops. The whole may, however, be looked upon as what is known to miners as a "blow," and affords no idea of what the width of the lode will be lower down. The lode has a strike N. 7° 30′ E.

"A shaft has been sunk to a depth of 60 feet on the main outcrop, and some earthy carbonates extracted and dressed. There being no means of descending the shaft, I was unable to ascertain the appearance of the lode at the bottom of it.

"Like most of the copper deposits in this district, the Mount Hope lode crops out on the top of a small hill."

Mr. Young stated the most probable cause of the elevation was mineralization of the country enclosing the lode during process of mineral deposition.

The Mount Hope outcrop presents features common to both the Cobar and Nymagee lodes, viz., ferruginous slates and sandstones seamed with quartz veinlets, striking about N. 10° E. Mount Hope consists of a long low ridge. The median line, or backbone, consists of a thick bed of sandstone, quartzitic in character, and is flanked east and west by ferruginous slates and alternating bands of sandstone. The quartz veins which seam the rock occur horizontally as well as vertically. Silicification, oxidation, and cementation of iron salts have greatly indurated the strata, destroying the fissility of the slates, and converting the sandstones partly into quartzites. The matrix of the lode as a rule is exceedingly hard, particularly in the sulphide zone, where the ore consists of an impregnated fine-grained sandstone. This induration increases the cost of winning considerably. The ore bodies are not defined within "walls" (which are conspicuous by their absence); in other words, they consist of segregations or replacements in the country itself without definite boundaries.

As is the case at Cobar and Nymagee, some of the surface ores were extracted by open cut at the one place where ores appeared in the outcrop. Below ground the longest longitudinal extension of ore measured about 400 feet, but was solid only for about 150 feet, the principal portion of this deposit having a width of from 60 to 80 feet. Beyond the furthest extension of this body of lodestuff no ore has been found, but practically no prospecting has been done beyond 100 feet north and south of the workings. It is regretable that during the prosperous days of the mine no attempt was made to test the considerable extent of ground lying north and south, which presents favourable indications of mineralization, though no copper ore appears at surface. Considering the large blanks in the Great Cobar Mine between the main ore bodies, it is possible that similar ones may occur at Mount Hope; at all events a trial is justified. Unfortunately prospecting,

NEW MOUNT HOPE COPPER MINE.
(Stope at 150-ft. level.)

New Mount Hope Copper Mine.

(Stope at 250-ft. level.)

owing to the hardness of the country, is now a costly undertaking, and beyond the means of the tributors who have been working the mine for some years. The General Manager, Mr. R. M. Kirk, however, states that the Company has offered to bear the cost of exploration. The cost of prospecting is further increased by the necessity for frequent crosscuts. The occurrence of ore bodies as isolated masses in the country renders it possible to miss them—as has been the case in the early workings—between ordinary levels and crosscuts.

The oxidised ores consist chiefly of earthy carbonates, with thin veins of red oxide and grey sulphide. As these ores are raised, the first grade goes from the breaker to the charging bins; the seconds pass from the breaker to Cornish rolls, and thence to Cornish jigs. As raised, the ore averages from 4 to 5 per cent; by dressing and jigging it is brought up to 14 or 15 per cent.

Sulphide ore has only recently been mined. Unfortunately, the fine sandstone matrix is extremely hard, and, still worse, iron sulphides are almost absent. The change to sulphides began about the 160-feet level, and passed completely into them at 270 feet. So far, only the hand-picked ore has been smelted. The sulphides, owing to the absence of iron pyrites, are high grade when clean, but are leanly distributed through the matrix.

The present concentrating plant consists of six Cornish jigs, which perform very clean work now that the ore is crushed to a finer mesh than formerly, but their capacity is very limited, and considerable time is lost in discharging the hutches twice a week. The absence of a flow of water prevents the hutchings (fines) from being as free from sludgy slime as would be possible with a continuous flow and discharge. About 1 ton of ore in 5 is obtained by this method of treatment. The Company has determined upon a larger and more efficient concentrating plant.

The seconds consist chiefly of light carbonates, having a reported assay value of from 5 to 6 per cent. of copper, though the later seconds of finer crushings would appear to fall below this estimate. Owing to the earthy nature of the carbonates in the large heaps of seconds from the early workings (7,000 to 8,000 tons, estimated), mechanical separation from the waste does not appear possible; a cheap leaching process alone would be effective. In another portion of this work this subject has received attention.

The smelting-plant formerly consisted of five furnaces, but two only are now in use. Fire-bricks are made from a sandy clay obtained at a depth of 60 feet, at a distance of seven miles from the mine. Its composition may be studied in the section devoted to fire-clays and bricks, where an analysis appears. It was first discovered in sinking a well for water. Most durable bricks are made from it direct after crushing. They are now burned in one of the old reverberatory furnaces. The Great Central Mine also draws its supply from this source.

The furnace charge contains about 23 cwt. of ore, a larger charge not being possible owing to its composition. It is made up as follows in barrow-loads, which run about six to the ton in ore and flux:—

4 barrows hutchwork (carb. and oxide fines).
2 ,, raggings (carb. and oxide fines).
1 barrow sulphides (hand-picked).
1 to 2 barrows picked slag (with prills).
1 barrow ironstone flux.
2 barrows charcoal.

Sometimes one of ashes is added. Four charges are reduced in twenty four hours. Since adding sulphides, a cleaner slag results than formerly.

The ironstone flux is carted from Mount Allen, a distance of ten miles, and forms a serious item in the expenditure. A large amount of this flux was used by the New Mount Hope Company before its auriferous nature was discovered, which resulted in the Mount Allen Gold-mining Company being formed. Gold-mining operations were established and successfully maintined for a time, until the yield fell below payable proportions. Cyanidation is now being resorted to for the large amount of ironstone tailings produced by battery treatment. The tailings were lately purchased by the copper company at 7s. per ton for fluxing purposes, but the supply has been stopped in view of the new treatment. The purchase, mining, and carriage of ironstone flux at the Mount Hope now entails an expenditure of 15s. per ton, which should cause the company to expedite the development of the sulphide resources of Mount Hope. Firewood costs 6s. 6d. per ton, and charcoal 37s. 6d.

RETURN of the yearly outputs and progress of the New Mount Hope Copper Mine, compiled from the Annual Reports of the Department of Mines:—

Year.	Ore raised.	Copper product.	Value.	Deepest shaft.	Deepest level.	Width of lode.	Number of furnaces.	Value of plant.	Men employed.	Remarks.
	tons.	tons.	£	ft.	ft.	ft.		£		
1883	2,088	431	22,000	268	150	(?)	Four Reverberatories.	7,612	200	Operations started by the New Mount Hope Copper Co. in April, 1881, but no returns are available for that and the following year.
1884	6,194	1,258	54,000	340	270	10 to 50	......	..	*236	
1885	3,796	635	..	..	..	..	......	..	..	Work suspended owing to low price of copper.
1886	..	..	..	..	..	..	......	..	..	A few hands employed at developmental work.
1887	..	..	..	..	..	..	......	..	..	Steps being taken to re-open mine.
1888	1,187	137	8,900	..	..	..	......	..	..	Ore to the value of £4,800 raised; 1,187 tons smelted.
1889	1,870	260	10,400	..	..	..	......	..	..	
1890	1,143	218	10,900	340	340	68	......	760	46	Worked on tribute.
1891	1,094	208½	9,158	340	340	58	......	700	36	" "
1892	(?)	190	6,283	340	340	..	......	..	40	" "
1893	(?)	(?)	6,501	340	340	..	......	..	40	" "
1894	892	135	4,054	340	340	..	......	..	36	" "
1895	858	143½	5,456	340	340	58	......	..	38	" "
1896	1,092	141½	5,660	340	340	..	......	..	36	
1897	784	(?)	5,840	340	340	..	......	..	40	
1898	992	131 tons 13cwt.	6,845	360	..	..	......	..	..	

Mr. R. N. Kirk, Manager of the Company, states that the total output of the mines, from the commencement of operations on the 30th April 1881 to 31st December, 1898, amounts to 5,070 tons 0 cwt. 3 qrs. 8 lb. of refined copper.

Nithholm Copper Mine, T. & A., Cooma Dn.—Situated on W. Jardine's Nithholm Estate, four and a half miles easterly from Cooma, and adjoining the Dartmoor Copper Mine property, Parish Montague, County Beresford.

NEW MOUNT HOPE COPPER MINE.

(Intermediate Stope between the 200-ft. and 250-ft. levels.)

The following particulars of bulk tests of ores from this mine have been supplied by Mr. J. R. Maccue, Cooma :—

No. 1 sample—7 cwt. 2 qrs., Walleroo Smelting Works ; copper, per ton, 29 per cent. ; silver, per ton, 16 oz.

No. 2 sample—1 ton 7 cwt. 1 qr., Walleroo Smelting Works ; copper, per ton, 8 per cent. ; silver, per ton, 18 oz.

No. 3 sample—1 ton 1 cwt. 2 qrs., The Smelting Company of Australia's Works, Dapto ; copper, per ton, 14·02 per cent. ; silver, per ton, 7 oz.

No. 4 sample—1 ton 12 cwt., The Smelting Company of Australia's Works, Dapto ; copper, per ton, 10·22 per cent. ; silver, per ton, 21 oz.

No. 5 sample—2 tons 2 cwt., The Smelting Company of Australia's Works, Dapto ; copper, per ton, 2·43 per cent. ; silver, per ton, 5 oz.

North Nymagee Copper Mine, C., Nymagee Dn.—Taken up adjoining the Nymagee Mine in 1880, and originally known as the Hartwood Mine. The south boundary of this property is but a short distance from the most northern open workings of the Nymagee mine, but notwithstanding a large amount of work no defined payable ore body has yet been discovered. At the boundary two shafts have been sunk, 200 and 293 feet respectively, and connected by a crosscut at the 200-foot level ; the connecting level intersects the strike of the Nymagee lode. At 30 feet west of the 200-foot shaft (No. 1), a channel, 13 feet wide, was cut in the crosscut. The filling consisted of broken country, with zinc blende and a little galena, and very rarely copper pyrites. So far this channel has not been driven on. Southerly, a short distance in the Nymagee Company's property, is an outcrop of ferruginous carbonate of lead, which apparently corresponds with the strike of the main lode.

Four hundred feet north from No. 1 shaft, No. 3 shaft has been sunk 112 feet. A little copper ore was found near surface, but none is showing in the shaft. The best deposit on this property was located 720 feet N. 55° W. of No. 1 shaft ; here a bunch of good ore was stoped out some years ago and sold to the Nymagee Company. The chute of ore was stoped 30 feet long from the 70 to the 130-foot level. This shaft is now 260 feet deep in a mineralised belt about 15 feet wide, carrying a little copper sulphide which might possibly be concentrated. This ore channel should also be driven on. The company is to be commended for the plucky persistence of unrewarded efforts. Possibly along the strike more concentrated ore bodies may occur. Recently some better class ore has been obtained in a drive along the ore channel southerly.

Northumberland Copper Mine, B., Bathurst Dn.—Situated at Dirty Swamp, in the Parish of Yetholme. Opened prior to 1878, but no work has been attempted for a long interval, and no particulars are available.

Nuntherungie Copper Mines, A., Broken Hill Dn.—Embracing the Cootra, Tarella Consols, and the recently named Wertego Mines. Situated about seventy-two miles from Wilcannia, on the Milparinka Road, and about fifteen miles from Nuntherungie home station, Parishes Wertego and Woraro, County Yungnulga.

In $\frac{1882}{p. 138}$, Mr. J. B. Jaquet, Geological-Surveyor, reported that more than twenty years prior several tons of copper ore, raised from shafts sunk near the western base of the Cootawundy Range, were sent to South Australia, *viâ* Wilcannia, for treatment. Notwithstanding the high price of copper then prevailing, it was found that the lodes could not be worked at a profit in that isolated district.

Mr. Jaquet further states that several lodes, composed of quartz with copper carbonates and decomposing copper pyrites, occur in the sandstones on the eastern side of the field. In some places carbonates, resulting from decomposition of pyrites, have been deposited in the interstices of the sandstone, which, from its copper-stained appearance, has given rise to an erroneous impression of a very broad outcrop of a copper-bearing lode.

The local Warden, Mr. J. W. Fletcher, under date 21st March, 1899, states that the copper-bearing country lies along the base of the Cootawundy (sometimes called the Copper Mine) Range, the cupriferous belt having a length of about 6 miles, by a width of 4 miles. Sixteen leases were taken up in February, 1899. The following extracts are from the Warden's report:—

"M.L.'s 125 and 126, Parish Woraro.—The copper outcrop runs the length of the two blocks, the lode being of good size. An old shaft, 25 feet deep, sunk on the lode in the early workings; 20 to 25 tons of ore at grass. There is also a fair-sized ironstone lode on the ground, carrying silver and copper.

"M.L.'s 113 and 114, Parish Wertego, lying south-east of M.L.'s 125 and 126, contain the old copper mine well. These blocks were formerly known as the Tarella Consols. The lode in them is reported to have been sunk on 110 feet. About 6 tons of dressed ore are lying at the mine, and a quantity of unsorted. The lodestuff consists of grey ore and green carbonates, in a gossan formation of good width. The lode is traceable through the length of the blocks, the width varying from 3 to 10 feet. An assay of the sorted ore is reported to equal 39 per cent. of copper, with traces of gold and silver.

"M.L.'s 118 and 119, south of M.L.'s 113 and 114.—A large lode of calc-spar is reported traversing these leases, with occasionally black oxide of copper.

"M.L. 121.—A large outcrop of blue and green carbonates and black oxide reported visible in this lease. A shaft 10 feet deep on a rich vein shows the latter rapidly increasing in width.

"M.L. 117, adjoining 118.—Bold outcrops of copper ore reported to be traversing this block, capable of being quarried.

"Adjoining 117.—A 20-acre lease has been taken up, covering a number of 'blows' of similar character and quality.

"M.L.'s 41 and 42, formerly known as the Cootra Mine, now the Wertego.—On these blocks outcrops stand out many feet above the surface, with blue and green carbonates and black oxides, for a width of from 60 to 100 feet wide. These outcrops are of lower grade than those further north, but easily available by quarrying.

"A large deposit of limestone is reported within a short distance, and abundant ironstone within 8 or 9 miles.

"M.L.'s 40 and 43 cover lodes exposed in small creeks falling from the range, showing carbonates and black oxide."

In connection with the above extracts from the Warden's report, it will be well to bear in mind the latter part of Mr. J. B. Jaquet's report quoted above, touching the deceptive appearance imparted to large outcrops of sandstone by the stainings of copper carbonates, arising from decomposition of a little disseminated copper pyrites.

Nymagee Copper Mine, C., Nymagee Dn., Parish Priory Plains, County Mouramba.—This mine was opened in 1880, having been floated into a company by Mr. Russell Barton. The earliest geological description dates from within three months of the beginning of mining operations, when Mr. L H. G. Young, accompanied by the Writer, visited the locality,

and reported as follows, $\frac{1880}{\text{p. 231}}$:—" The slate rocks adjoining the copper deposits are of a sandy character, and have a strike of N. 24° W., dipping to the south-west at an angle of 68°. At Nymagee Mine there appears to be two lodes. The main lode has a strike of N. 17° 30′ W., and is nearly vertical; three shafts have been sunk upon it, at a distance of 276 feet apart. To the east of the middle shaft (No. 3) may be seen the outcrop of a branch lode, having a strike of N. 9° E., and which as yet remains unexplored." In the three shafts sunk at that date to (1) 120, (2) 55, and (3) 80 feet, respectively, the width and composition of the lode at these levels were (1) 8 feet wide, composed almost entirely of yellow sulphide mixed with black oxide of copper; at (3) 55 feet the lode is 8½ feet wide, and is composed of earthy carbonates, grey sulphides, and red oxide of copper, mixed with decomposed slate and brown iron ore; at (2) the lode is 5½ feet wide as yet, but the whole width has not been exposed; it contains large masses of brown iron ore, and grey sulphide, and red oxide of copper."

"The second lode on this property is called the 'East Lode.' It has a strike N. 18° W., and is composed of argillaceous matter, earthy carbonates, red oxide, and grey and yellow sulphides of copper, the latter only in patches."

In November, 1898, the Writer visited the mine, but unfortunately, owing to failure of the water supply—the first time for a number of years—mining operations had practically ceased, and it was not possible to inspect below the 40-fathom level. Nymagee, like Cobar, has to contend with an arid climate and waterless surroundings. During a severe drought in 1882–3 copper to the extent of over 1,300 tons accumulated at the mine, owing to impossibility of transport. The remarks under the head of Great Cobar, touching initial difficulties, apply equally to Nymagee, Great Central, and Mount Hope Mines. The main shaft reached its lowest depth—734 feet—in 1890; the deepest level was driven at 720 feet. The lode at this level is reported to be 30 feet wide, and composed of massive pyrites, containing about 2 per cent. of copper, though a couple of narrow seams of good grade occur. In 1896 the mine was purchased by the Great Cobar Mining Syndicate, who substituted a blast-furnace for reducing, and subsequently established pyritic smelting, heap roasting being discarded. The reverberatory furnaces have been retained, however, for matte roasting, the latter being brought up to high grade before dispatching to the syndicate's refinery at Lithgow, the distance to the nearest railway station (Hermidale) being forty-five miles.

The syndicate has not worked below the 600 feet level since obtaining possession of the mine. Operations have, so far, been largely confined to robbing the old stopes of left and discarded ores.

Fire-clay is obtained about three miles from the mine, and is mixed with crushed quartz in the manufacture of fire-bricks. Its composition may be seen under the head of "Fire-clays."

The quality of Nymagee copper has always been remarkably pure and free from injurious associates. An assay of the refined copper returned 99·74 per cent., and silver at the rate of 3 dwt. per ton, but no gold.

The main sulphide ore body averaged about 250 feet in length by about 15 to 20 feet in width, and yielded on an average about 10 per cent. of copper.

Several parallel smaller veins have been opened in cross-cuts east from the main workings.

The carbonate ores were extracted largely by open cut, and a little of this ore is still obtainable.

The Nymagee outcrop closely resembles that of Cobar, save that the slates and sandstones stand up more conspicuously above the ordinary surface; they strike N. 30° W. The outcrop of copper ore was comparatively small and confined to one spot, which has since been exploited by open cut. In only two places was iron oxide noticeable on the surface. One of these, at the south-east end, has not yet been extensively prospected. Copper carbonates stain, many of the joint and cleavage planes of the strata to the eastward of the main outcrop, but no defined lodes have been exposed.

The extent of the output, and the progress of development, is shewn in the following table of returns:—

RETURN of the Yearly Output and Progress of the Nymagee Copper Mine; compiled from the Half-yearly Reports of the Nymagee Copper Mining Company, Limited, and the Annual Reports of the Department of Mines and Agriculture.

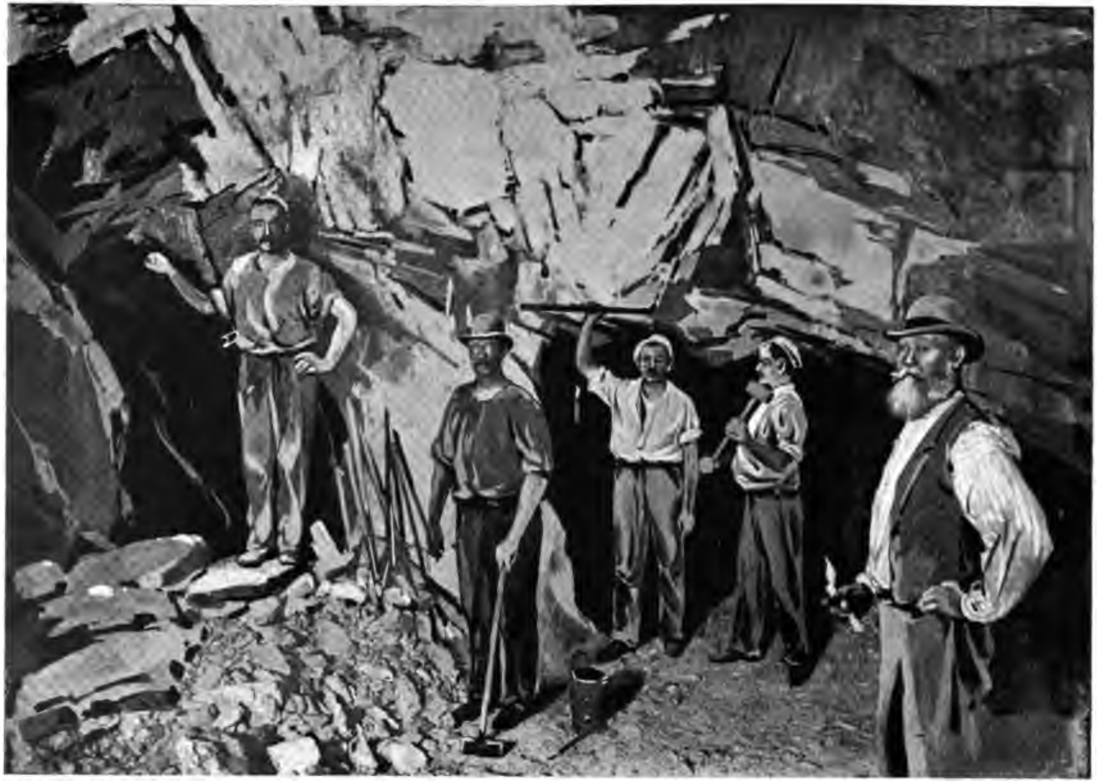
Year.	Ore Raised.	Ore Smelted.	Copper Produced.	Percentage.	Value.	Deepest Shaft.	Deepest Level.	Width of Lode.	Men Employed.	Remarks.
	tons.	tons.	tons.		£	feet.	feet.	feet.		
1881	6,571	6,053	859	13·61	60,000	240	240	15 to 25	..	This amount represents the output since starting in 1880.
1882	7,677	6,618	1,144	17·18	80,000	270	240	2 to 30	500	
1883	10,568	10,236	1,714	16·75	96,000	390	310	3 to 18	..	
1884	14,748	14,743	2,207	14·95	....	390	..	4 to 12	..	
1885	16,310	15,773	1,791	11·35	80,000	528	480	4 to 12	350	52,000 tons of wood consumed annually.
1886	14,372	14,449	1,463	10·15	60,967	528	516	4 to 12	300	
1887	9,861	10,739	1,036	9·64	48,107	628	618	10 to 25	350	
1888	12,472	12,826	1,297	10·11	91,000	734	..	8 to 20	250	Copper boom year.
1889	8,585	8,704	836	9·60	39,000	734	720	8 to 20	250	Collapse of copper boom and fall in values.
1890	7,954½	8,098	792	9·78	43,868	734	720	8 to 20	250	
1891	9,482	9,537	916	9·60	45,050	734	720	....	..	
1892	6,238	....	697	11·01	31,600	734	720	....	..	
1893	....	....	....	..	....	734	720	....	..	Mine closed owing to the low price of copper.
1894	1,638	....	148	8·76	5,940	734	720	....	120	
1895	5,845	....	485	8·29	21,825	734	720	....	150	Mine worked on tribute.
1896	3,249	....	380	11·08	17,948	734	720	....	..	Purchased by the Great Cobar Mining Syndicate.
1897	11,910	....	510	4·28	....	..	..	....	..	Supplied by Dr. Read, Managing Director.
1898	17,152	....	728	4·53	....	..	..	....	..	

Dividends.

1 September, 1883—1st of 5s.
1 October, 1883—2nd of 2s. 6d.
20 February, 1884—3rd of 2s. 6d.
26 June, 1884—4th of 2s. 6d.
1 September, 1885—5th of 1s.
4 January, 1888—6th of 1s.
25 April, 1888—7th of 1s.
6 June, 1888—8th of 1s.
11 July, 1888—9th of 1s.
15 August, 1888—10th of 1s.
12 September, 1888—11th of 1s.
10 October, 1888—12th of 1s.
14 November, 1888—13th of 1s.
19 December, 1888—14th of 1s.
6 March, 1889—15th of 1s.

Making a total of £94,000 paid in dividends during the existence of the Company, equal to £1 3s. 6d. per share.

Ophir Copper Mine, B., Orange Dn., south-east of Lewis Ponds, County Bathurst.—In 1852 a company was formed to work this mine, and a Bill to incorporate was presented to Parliament in 1853. Ores from the mine were exhibited at the Paris Exhibition of 1855. No particulars are available of the early operations. In *Mineral Statistics of New South Wales*, 1875, p. 91, the Company is referred to as working a lode at Brown's Creek having an average thickness of 2 feet; a north and south strike, and an easterly dip of 1 in 6; proved to 150 feet. Ores consisted of carbonates, oxides, and



Nymagee Copper Mine.
(100-ft. level.)

NYMAGEE COPPER MINE.

(240-ft. level.)

sulphides (containing gold) in a quartz matrix. Two hundred tons had yielded 30 tons of copper. Twenty men were employed. This lode was afterwards worked by the Great Western Copper Mining Company, which see.

Orange Plains Copper Mine, L., Trundle Dn., one mile west of Tabratong Station, on the Bogan River.—Opened by Mr. T. Richardson in 1884. The outcrop occurs on a small rise, and consisted of gossan and grey ore. The lode was opened about 60 feet on the underlay, its thickness being from 4 to 5 feet. No payable ore body, however, was disclosed.

About three miles east of this mine, blue and green carbonates of copper occur in slate. No work has been done, though the site was once taken up.

Paddy Linda Copper Mine, T. and A., Cooma Dn., Parish Jindabyne, County Wallace.—Situated on A. Sturgeon's purchased land. Discovered about 1884.

Parkes District, L., Parkes Dn.—Copper ores occur in small quantities in numerous localities in this district. The following have been noted:—

Goobang Station, five miles north-west of Parkes.—Copper ore discovered in $\frac{1882}{\text{p. 54}}$, and a few tons raised.

Gobandry, eight miles north-west of homestead.—Copper ore prospected about twenty years ago to 50 feet. Traces only exposed.

Goonumbla Hill, thirteen miles north-west of Parkes, on Goonumbla Road, also four miles S.S.W. of Goonumbla Hill, on the main range.—Copper ores occur.

Limestone Reserve, six miles north-west of Parkes.—In $\frac{1888}{\text{p. 66}}$ a shaft was sunk 110 feet in a lode striking north-east and south-west. Twelve tons of ore raised.

Gunningbland Station, eighteen miles west of Parkes.—A strong outcrop of iron-stone, carrying copper carbonates and galena, occurs here, which was partly opened under prospecting aid in 1898, but unsuccessfully.—(*See* Gunningbland Copper Mine.)

Little Mount Currumbla Station, twelve miles west of Parkes.—Native copper occurs here in andesite with quartz and epidote.

Langford's Lease, twelve miles north of Parkes.—Owner states that the lode in this lease has been traced on surface for about 190 yards by cuttings and trenches, the deepest 18 feet. Lode about 1 foot thick. Assays of samples returned 7 to 30 per cent. of copper.

About one and a half miles east and also west of this lease, copper indications also occur, according to Mr. Langford.

Welcome Reef.—Close to this reef, about two miles from Parkes, on the Forbes line, Mr. J. Stott reports copper ore. Opened out some years since to a shallow depth.

Trundle, four miles south-east and the same distance north-east in the same belt of slate, copper indications occur—in one instance native copper—but nothing payable known, though aid was granted one site from the Prospecting Vote.

Cumnock, five miles west on Peak Hill and Dilga Road, a patchy copper vein was opened twenty-five years ago to a depth of 30 feet. Taken up again about nine years since. Nothing payable or permanent discovered.

Payne's Mine, Reedy Creek, Bumbery.—(*See* Bumbery Mine.)

Peabody Copper Mine, L., Molong Dn., six miles southerly from Molong, close to the Cudal-road.—Rich bunches of copper ore at surface. Opened about 1872. No particulars available, though copper ores from this mine were exhibited at the Philadelphia Exhibition in 1875, by Mr. S. L. Bensusan.

Peel River, P. & U., Nundle Dn.—On the 7th May, 1853, the Rev. W. B. Clarke recorded the occurrence of malachite in the neighbourhood of the Peel River. Probably this was at the site of the subsequently opened Dungowan Copper Mine (which see).

Peelwood Copper Mine, B., Tuena Dn., ten miles from Tuena.—The first official record of this mine is contained in *Mineral Statistics* 1875, p. 91. The lode is herein stated to have been 4 feet in thickness, striking north and south and dipping east at 15°. The footwall country is schist, and the hanging wall soft slate. Silver and lead ores were associated with the copper ores. A shaft had been sunk 384 feet, and about 1,900 tons of ore raised to that date, 1,100 of which had been smelted for an average yield of 12½ per cent. of copper. Three reverberatory and one calcining furnaces were in use.

During $\frac{1874}{\text{p. }22}$ 322 tons of ore were raised, which yielded 32 tons 4 cwt. of copper, valued at £3,220.

In $\frac{1876}{\text{p. }36}$, the Mine Manager (Mr. Williams) supplied the local Warden with the following particulars:—"During the past year the mine has been sunk 120 feet diagonally [On the underlay of the lode.—J.E.C.], making a total depth of 420 feet from the surface. Bearing of lode north and south underlying eastward at an angle of 45°. The lode contains copper, lead, zinc, and silver, and varies in thickness from 1 foot to 20 feet. Throughout the mine there is abundance of lead ore, containing a good deal of silver, which is smelted with the copper ore, thus rendering the produce in regulus, which contains from 40 to 50 per cent. of copper, 30 to 40 per cent. of lead, and from 100 to 130 oz. of silver per ton. The mine, during 1876, has produced in regulus and lead 300 to 350 tons.

"The working plant consists of two large portable engines, with crushing and dressing machinery, four reverberatory furnaces, and a calciner. The latter is used for desulphurising and expelling fumes of zinc, preparatory to smelting operations, otherwise there would be great difficulty in obtaining separation of the slags and metals."

The progress of the mine from 1876 is briefly recorded in the following extracts from the Annual Reports of the Department of Mines:—

In $\frac{1877}{\text{p. }58}$ mine reported steadily at work raising and smelting ores, but returns are not given.

$\frac{1879}{\text{p. }99}$ mine shut down, causing a great blow to the district; subsequently re-started by local men.

1880.—Mine worked regularly. 136 tons of copper produced, valued at £5,444.

1881.—Peelwood Tributors reported steadily at work, but no returns given.

$\frac{1882}{\text{p. }24}$—950 tons of ore raised, valued at £2,910. Mine closed before the end of the year.

1883–4–5—No records. Mine apparently closed.

$\frac{1886}{\text{p. }49}$—Mine changed hands after being idle for several years.

1887.—No records.

$\frac{1888}{59}$—Twenty-four men employed.

From this date no further work appears to have been carried on. The sulphide ores at bottom are undoubtedly very zinciferous, the proportion being about—copper, 4 per cent.; zinc, 25 per cent. A water-jacket furnace was erected in 1888, during the silver boom.

Nymagee Copper Mine.
(250-ft. level.)

It is interesting to note that the rare elements, "gallium and "indium," have been detected in the blende (zinc sulphide) of Peelwood, by Mr. J. B. Kirkland, F.C.S. (Assistant Lecturer and Demonstrator of Chemistry, University of Melbourne), who made the following analysis of the Peelwood ore:—

Silica	6·05	
Lead	16·71	containing 11 to 12 oz. of silver per ton.
Iron	11·06	
Copper	5·60	
Zinc	28·77	
Sulphur	29·21	
Loss, &c.	2·30	
	100·00*	

Pinnacles, A., Broken Hill Dn.—The following particulars of copper lodes in this locality have been obtained through the local Warden:—

"Several copper bearing outcrops occur within a radius of about fifteen miles, the two most important and promising being one prospected by Messrs. Lord and Party, about four miles west of Pinnacles. This outcrop is reported traceable for a considerable distance. Copper indications occur in it at intervals. Assays have yielded from a trace to 50 per cent. of copper.

"The second promising lode is situated about two and a half miles south-west of Pinnacles. It was opened about thirty years ago, and a consignment of copper ore is reported to have been dispatched to Adelaide. This lode is stated to be strong in the outcrop and traceable for a considerable distance."

Port Macquarie, H. & M., Kempsey Dn., south of Nobbys, the south headland of Port Macquarie.—A lode containing iron and copper sulphides was opened about twenty-six years ago by tunnel from the sea coast, without, however, any satisfactory results being obtained. Assays of the lodestuff in 1880 yielded from 2·13 to 5·05 per cent. of copper, and about 2 dwt. of silver per ton.

Prince of Wales Copper Mine, P. & U., Bingara Dn., Bobby Whitlow Creek, Bingara District.—In $\frac{1878}{p.179}$ Mr. L. H. G. Young reported that the results of exploration in the outcrop, though encouraging, were not sufficient to warrant an opinion of the extent or value of the lode. The lower levels were then under water. In 1878, 8 tons 6 cwt. and 1 ton 17 cwt. of ore from this lode were treated at the English and Australian Co.'s works, Waratah, for yields of 18¾ and 6¼ per cent. of copper respectively.

Later reports state that the mine was idle after No. 1 shaft had been sunk 100 feet and No. 2, 24 feet. 200 tons of ore were reported to have been raised. In $\frac{1882}{p.90}$ the mine was again taken up, but apparently nothing has been done since that date.

Prospect Copper Mine, Cow Flat, B., Rockley Dn.—In $\frac{1880}{p.52}$, 30 tons of ore were raised from this mine, and sold for £117. In $\frac{1881}{87}$, 17 tons of ore raised yielded £25, which, smelted at Lithgow, yielded 1 ton of copper. Probably, the above outputs exhausted the visible ore supply, as no further records are available.

Purnamoota, A., Broken Hill Dn.—Messrs. Davison and Ayliffe reported through the Warden (1898) that good surface indications of copper occur

* Austr. Assoc. Advancement of Science, 1892, iv, pp. 266–7.

in several localities in the neighbourhood of Purnamoota, but are of no great depth. At Terrible Dick very good specimens were obtained at surface, but carried down only 30 or 40 feet. Similar conditions prevail at the Paragon Mine.

Pye's Creek, N.E., Deepwater Dn., fourteen miles N.N.W. of Deepwater and one mile from Cadell's out station on Pye's Creek.—A lode about 4 feet thick is reported to occur at the above locality, consisting of copper and iron pyrites, galena, and zinc blende. Bunches of rich copper ores occur at intervals. Opened about 40 feet by shaft, and driven on for 20 feet. About 40 tons of mixed ore at grass. No bulk tests made. Assays yielded up to 20 per cent. of copper from best bunches. Numerous indications are reported to occur in neighbouring veins and lodes.

Queanbeyan District, T. & A., Queanbeyan Dn.—Copper indications occur n and near the town of Queanbeyan, but nothing payable or permanent has yet been discovered. Copper ores are also reported from near Rose Valley, assaying ($\frac{120}{98}$) 9·02 per cent.; from six miles from Queanbeyan, assaying ($\frac{4702}{97}$) 13·08 per cent. of copper. From McDonald's Mine, Uriara, sixteen miles from Queanbeyan, copper ore, yielding ($\frac{37}{98}$) 6·54 per cent. has been forwarded.

In the *Australian Mining Standard* of the 24th November, 1898, a discovery of copper ore is reported at London Bridge, near Queanbeyan, and a contract let to sink 100 feet upon it.

At Congwarra (which see) more extensive copper deposits occur.

Quedong.—(*See* Belmore Mine.)

Queen of the Stream Mine, T. & T., Sofala Dn., four and a half miles west from Capertree, Parish Rylstone, County Roxburgh.—The discovery of this mine by Franks and Party was announced in the *Australian Mining Standard* of the 10th June, 1897. Lode reported well defined. Assays have yielded 20 per cent. of copper and 58 oz. of silver per ton.

Quigley's Hill Copper Mine, B., Blayney Dn., about five miles south of Blayney.—A thin vein of copper pyrites was followed down in this mine for about 140 feet in sedimentary rocks—slates and sandstones. The channel rock consists of greasy jointed and cleaved slates. Mr. D. Milne, Inspector of Mines, states that at 100 feet the vein was about 6 inches thick. Nine tons of ore sent to Lithgow for trial yielded 9 per cent. of copper. This amount, judging from the tip, is all the ore raised during operations.

Recovery Copper Mine, C., Bobadah Dn., Top Tank Paddock, Overflow Run, eighteen miles north-east of Overflow Silver Mine.—Held as a mineral lease of 40 acres. Shaft sunk 100 feet, and driven east 45 feet. The vein occurs in soft micaceous slate and sandstone, and consists of ferruginous quartz with a little copper and lead carbonates, about 12 to 18 inches thick. Assays of picked samples ($\frac{1165\text{-}6 \text{ and } 1534}{97}$) yielded from 15 to 42·5 per cent. of copper. The vein is reported to have pinched out or been lost in sinking. Of no value as a copper lode. A few dwt. of silver, and, in one instance, 19 dwt. of gold per ton, have been obtained in assays.

Red Hill Mine, S., Yass Dn., about fourteen miles from Yass, near the head of the Burrowa River.—According to Mr. A. McCullum, of Yass, this mine is being worked for gold and copper. In sinking the main shaft (110 feet), ironstone was passed through for 40 feet, then copper carbonates to 75 feet. At 110 feet sulphide ore is being worked. An east and west crosscut for 30 feet reveals no walls.

Reedy Creek, L., Molong Dn.—On the 12th April, 1852. Mr. S. Stutchbury reported: "At 300 yards from Reedy Creek, and half a mile from the station hut, which bears E. 10° S., is a mound of porphyry, composed of a red paste with crystals of felspar, traversed by veins of prehnite. Masses of ore have been found with native copper, several large lumps of which have been found. One, weighing 102 lb., is now in the possession of Mr. Smith." Probably this lump is identical with the exhibit at the London Exhibition of 1851, consisting of 1 cwt. of native copper from Reedy Spring, the property of the late Mr. Smith of Gamboola Station, near Molong. A similar block, weighing ¾ cwt. from the same locality, is now at the station homestead.

(*See* also Payne's Mine.)

Rockdale Gold and Copper Mine, L., Jewnee Division.—P.G.L.1, Parish Warri Warral, County Clarendon, Junee Reef.—The owners of this mine—Baker and Party—report that in sinking their main shaft, at a depth of 60 or 70 feet, a band of blue and green carbonates of copper was struck, having an average width of 1 ft. 6 in. This ore continued in the shaft for about 8 feet with a northerly dip. At the lowest level yet attained, 100 feet, the reef consists of ferruginous quartz, stained with copper carbonates. Samples of the blue carbonates assayed 24·96 per cent. and the green about 12 per cent. In the former a return of 6 oz. 9 dwt. of silver was also obtained. From this mine it is also reported that samples of the auriferous portions of the reef treated at Wyalong, and Footscray and Ballarat (Victoria) have yielded from 3 to 7 oz. of gold per ton. Ordinary battery treatment is reported unsuitable for extraction.

Rockley District, B., Rockley Dn. (*See* Cow Flat, Apsley, Belmore, and Summerhill Copper Mines).—Copper ores occur in numerous places in this district. Besides those above-mentioned, the following have been reported:—

Back Creek.—Samples assayed $\frac{2662}{96}$ and $\frac{4432}{97}$ yielded 30·16 and 11·86 per cent. of copper.

Mountain Run, six miles from Rockley. Samples assayed $\frac{4960}{97}$, copper 12·13 per cent.; silver, 10 oz. 10 dwt. per ton.

Rockley, five miles east.—Sample $\frac{2968}{97}$, copper, 21·05 per cent. ($\frac{1917 \text{ and } 1918}{98}$); copper, 16 to 17·67 per cent.

Rockley, eight miles north-west.—Sample $\frac{3664}{97}$, copper, 32·52 per cent.; silver, 2 oz. 3 dwt. per ton.

About seven miles north-west of Rockley, and one and a half mile west from the Rockley Bathurst Road, Parish Ponsonby, County Bathurst.—Mr. Milne reported $\frac{2322}{98}$ Pros. Papers, that Byron and Party were prospecting for copper in schist country. Shaft 110 feet, stoped on south end. Some years back a bunch of fair ore was worked from surface to the 110-feet level where sulphides were met. The oxidised ores were stoped out for a length of about 60 feet, pinching at each end of the stope. At this stage the mine was abandoned. The channel is described as well-defined and the outcrop strong. From the shaft the present owners have raised 6 tons of ore, which yielded 7·5 per cent. of copper. Aid granted to continue prospecting.

The Mining Registrar, in his report for 1898, states that Jamison and Party have taken up 280 acres for copper mining at Sugar-loaf, on Church and School lands, and having sunk three shafts are satisfied with the prospects.

Black Mount, about one mile N.W. from Charlton House, about five miles N. of Rockley. Mr. H. Hooke, Inspector of Mines, (Pros. Papers $\frac{1894}{99}$) describes the lode as well-defined and likely looking, country slate. Aid granted to prospect.

Rockvale.—P. & U., Armidale Dn.—The Mining Registrar, in 1898, reported the occasionally occurrence of copper sulphides in the Phœnix Gold mine.

Rosebrook Mine (Hayes, Jennings, and Party's), Portion 12, Parish of Umeralla, County Beresford, T. & A., Cooma Dn.—Held as a 10-acre lease on the Rosebrook Estate. Shaft 40 feet, in slate country. From this mine the following parcels of ore were treated at the Smelting Company of Australia's Works, Dapto:—

2 tons, yielding 14 per cent. copper, 11 dwt. of gold, and 2 oz. silver per ton.
2 „ 10 „ „ 9 dwt. 4 grs. of gold, and 2 oz. silver per ton.
1 ton 5 cwt., yielding 16 per cent. lead, 11 dwt. of gold, and 13 oz. of silver per ton.

Rosella Copper Mine, B., Rockley Dn., one mile north-east of Essington Copper Mine.—Prospected between 1870–75; shaft sunk 90 feet. Nothing payable discovered.

Rose Hill Copper Mine, M., Dubbo Dn., about four miles south of Genrie Railway Station, Parish Mickety Mulga, County Lincoln.—The Warden in $\frac{1888}{p.70}$, reported that three shafts had been sunk on a lode about 2 ft. 6 in. thick, and well defined. The depths of proving being 25, 40, and 90 feet. The ore consisted chiefly of yellow sulphide. A trial parcel of 4 tons was sent to the English and Australian Co.'s Waratah Smelting Works; but as work ceased in 1889, it is presumed that the result of the trial was not satisfactory.

Scottish and Australian Copper Mine, C., Cobar Dn., nine miles N.N.W. of Cobar, Parish Kalooleguy, County Robinson.—This mine was opened in 1882. After forfeiture, was taken up again in 1886. In 1888 it was prospected by the Cobar Copper Mining Co. Two fresh shafts were sunk 100 and 120 feet, and drives extended, but without favourable results.

Shelly's Flat, S., Goulburn Dn., about four miles from Marulan.—The Rev. W. B. Clarke, in June, 1852, mentioned the presence of copper in this locality.

Silverton, A., Broken Hill Dn. (*see* also Barrier Range).—The following particulars of copper lodes in the neighbourhood of Silverton have been supplied to the local Warden by Mr. R. H. Srezise, under date July, 1898:—

"We first tried in the hills to the west of the Umberumberka Mine for four weeks, but abandoned the site after obtaining 30 cwt. of 10 per cent. copper ore in the time mentioned. We then tried in the hills on the east side, and succeeded in raising 10 tons of 11½ per cent. copper ore in eight days; but it proved only a pocket in a big lode formation, and as it cut out entirely at 9 feet we abandoned this site also, and pegged out a third area about 2 miles north on the same line of lode. In twelve days we have raised about 9 tons of ore, averaging about 13 per cent., and are now sinking a shaft.

"Barron and Party are obtaining good results from near Mount Robe. Several trucks of ore have been dispatched, believed to contain 23 per cent. of copper.

"Near the old racecourse, Casey and Party are reported to be raising payable ore."

Two other parties were at work near the Old Silverton Copper Mine, one of which had dispatched a parcel of ore, from which good results were anticipated.

Smith and McGuinness' Mine, B., Canowindra Dn., Portion 62, Parish Malongulli, County Bathurst, near Sugarloaf.—Aided to sink in andesite, showing stains of carbonate of copper near the surface and particles of native copper in the unweathered rock. Abandoned.

Snowball Copper Mine, T. & A., Adelong Dn., about nine miles from Gundagai, towards Adelong, Portion 168, Parish Willie Ploma, County Wynyard.—Situated on Snowball Hill, at the head of Snowball Creek, a tributary of the Murrumbidgee River.

This lode was discovered by James Clayton, of Gilmore, in 1873, close to the marked-tree line on the mountain track between Adelong and Gundagai, who took up a lease in conjunction with his two brothers. Later, other leases were acquired, and the property passed into the possession of a company.

The earliest official record is that by Mr. W. H. J. Slee, Chief Inspector of Mines, in $\frac{1876}{p.125}$, to the effect that thirty men were then employed and a furnace was being erected. Gossan outcrop traceable for about 1,000 feet, but lode only opened for about 100 feet in length. Assays of yellow sulphide reported to yield from 7 to 22 per cent. of copper.

In 1877 a syndicate to properly work the mine was proposed by Mr. S. L. Bensusan. At this time it was reported that the lode in the deepest shaft—100 feet—was 10 feet wide, and consisted of yellow sulphides, averaging about 10 per cent. Other shafts, 45 and 70 feet deep, had the lode from 5 to 9 feet wide, 3 feet of which was reported to be good carbonate ore. Four other shafts had been started on tribute. A tunnel was being driven at right-angles to intersect the lode in the main shaft at the 136-feet level.

In the same year, $\frac{1877}{p.169}$, Mr. Slee reported the deepest shaft as 130 feet; lode 10 feet wide, slaty, with solid bunches of sulphide ore. Two furnaces were in full work, and a third in course of erection. Population, about 150.

In 1878–9 the Warden reported considerable activity at Snowball, and anticipated fair prospects of success when the railway line to Gundagai was completed.

In 1880 the Mining Registrar reported the abandonment of smelting operations.

In 1881 the property was purchased by Messrs. Benson and Samper, but apparently no work was done, the mineral conditional purchase into which the lease was being converted being cancelled for non-payment of balance due. Later it was taken up as a conditional purchase.

In 1895 and 1896 Mr. Benson partly unwatered the mine and extracted 12 tons of ore from the 175-feet level, and 6 tons from the 100-feet. The two parcels are stated to have averaged 7 per cent. of copper at Mr. Lloyd's Smelting Works, Eskbank.

Recently the mine was visited by the Writer. The country consists of slate and igneous rock—partly epidotic—the lode apparently occurring as a junction deposit. The outcrop is a strong one and extends from some little distance. The workings, however, were confined to about 300 feet in length. The strike is nearly east and west; dip vertical. The old workings are unsafe, and water prevents inspection below 120 feet; but, judging from the old stopes, the ore channel is a wide and strong one, though the ore has evidently been bunchy in places. On one wall slickensides are well developed, which indicates considerable movement and therefore permanency. At the west end of the workings a cross-course divides the lode; but as ore is seen in the country beyond, there is no apparent faulting. A siliceous, gossany outcrop a short distance to the west-north-west is regarded by some as the faulted continuation of the lode, but sufficient work has not been done to test this question. A sample of the gossan assayed ($\frac{588}{99}$), yielded 0·01 per cent. of copper only, which is no guide, as copper is likely to be detected in the country for some distance in this cupriferous locality.

A sample of the rejected ore from the 175 feet level, extracted by Mr. Benson, was assayed $\frac{682}{99}$ with the following results:—

Copper	1·87 per cent.
Iron	18·49 „
Silica	39·00 „
Neither gold nor silver.	

It is evident that the lower levels of the lode constitute a concentration problem, though bunches may be found of direct smelting ore, as at higher levels.

It has not been possible to ascertain the quantity of copper produced during the smelting operations; but, judging from the slag dump, which roughly measures from 4,000 to 5,000 tons, it must have been fairly considerable, as some of the ores were of high grade.

Sofala, T. & T., Sofala Dn.—An old copper mine is reported at the head of Jews' or Wallaby Creek, on the range about five miles south-west of Sofala.

Solferino, C., & R., Solferino Dn.—The Mining Registrar in $\frac{1876}{p.\ 113}$ reported the occurrence of a copper lode eight miles north-east of Solferino, 1 ft. 6 in. thick at the outcrop. In a 20 feet shaft the width had increased to 2 feet, the ore assaying 26 per cent.

Another lode was reported 6 miles east of Solferino; shaft, 20 feet; lode, 1 ft. 6 in. thick; strike, east and west; an assay of ore from it yielded 56 per cent.

Southern Cobar Copper Mine, C., Cobar Dn.—Taken up by Joseph Becker in May or June, 1871, adjoining the Cobar Mine on the south. Worked by the Southern Cobar Copper Mining Company Limited, until January, 1876, when the two mines were amalgamated under the title of the Great Cobar Copper Mine.

Renwick's Shaft—frequently mentioned in the reports of the Great Cobar Company—formed the main shaft of the Southern Company. It was sunk within about 40 feet of the south boundary of the Cobar property.

Though this mine become so early incorporated with the main mine, it is interesting to regard it separately up to the time of amalgamation, as the prospecting operations therein have an important bearing on the prospects of the southern continuation of the Cobar lode, in which direction work is not now proceeding.

The Southern Cobar Company was floated with a capital of 80,000 shares of £1 each.

The following particulars have been extracted from the Half-yearly Reports of the Company.

Fourth Half-yearly Report, 26th August, 1874.—Main shaft 40½ fathoms lode, 20 feet wide. Preparations for two furnaces being made.

During the half-year 220 tons of good ore raised, and 150 tons dispatched from the mine. The quality of the ore can be judged from the following account sales from Messrs. Stilling, & Co., of Adelaide :—

Tons.	Assay, per cent.	Net return.
15	40¾	294 18 10
58	35¾	
22	26⅝	1,204 2 4
14	27⅜	
8	43⅛	305 2 4
5	44⅝	109 16 6
12	38¼	
4	26⅜	243 3 5
13	36¾	231 9 3
15	37⅛	
4	26¼	610 4 9
14	42¼	
		£2,998 17 5

During the half-year ending 31st December, 1874, the main shaft was deepened to 46 fathoms. At 35 fathoms the lode was cut in a cross drive west 122 feet from the shaft, and was found to be only 7 inches thick. A winze sunk, following the lode from the 25-fathom level to the 35-fathom, proved it small and unprofitable.

Operations during the sixth half-year were confined to raising ore from the 15 to 25 fathom levels, and to prospecting. No ore was obtained in either the 35 or 45 fathom levels.

At the 35-fathom level the lode channel was driven on 247 feet north, 24 feet of which alone bore stains of copper. The lode varied in width from 3 inches to 3 feet, consisting principally of slate (in some places quartz), strongly stained with iron.

At the 45-fathom level the lode, intersected in a crosscut west 176 feet in length, was contracted to a mere division in the strata, showing no signs of copper.

The following additional returns were received from Adelaide :—

Tons.	Assay.	Net return. £ s. d.
3	43 per cent.	63 5 1
23¼	44 ,,	542 7 4
30½	42 ,,	671 14 9
6½	43½ ,,	150 16 5
18	42¾ ,,	475 3 1
12½	39½ ,,	264 4 8
	93¾ ,,	2,167 11 4

During the first half of 1875, two smelting furnaces were completed and a third begun; 316 tons of ore were smelted, yielding about 45 tons of coarse copper; ore at grass valued at £3,945.

South Wiseman's Creek Copper Mine, B. Rockley Dn., on the south bank of Wiseman's Creek, opposite and on the same lode as the Wiseman's Creek Mine.—The earliest record of this mine is contained in *Mineral Statistics*, 1875, p. 92, in which the depth of proving is given at 120 feet. Assays returned 9 to 20 per cent. of copper, and 9 to 20 per cent. of lead, and traces of gold and silver. Two hundred tons of ore had been raised, and sold at £6 10s. per ton.

In 1876 and 1877 the mine was idle. In the latter year it was visited by the late Government Geologist, Mr. C. S. Wilkinson, who stated that it was apparently on the same line of fault as that in which the Wiseman's Creek Mine is situated. During $\frac{1878}{p.\ 97}$ a little work was done near the surface for carbonate ores. In $\frac{1885}{p.\ 61}$ the presence of silver in some quantity having been detected in the lodes of Wiseman's Creek, considerable attention was directed to them. A tunnel near the creek level was at this time started in the South Mine.

Recently attention has again been directed to the locality, chiefly owing to the substantial rise in the value of copper, and a little work is being done in cleaning out and repairing the main shaft and tunnel preparatory to further development. The Wiseman's Creek ores are unfortunately largely contaminated with zinc sulphide, which renders them very refractory. (*See* Larry's Hill Copper Mine.)

Sugarloaf Copper Mine (Wright and Osborne's), B., Blayney Dn., about two miles south of Blayney.—Discovered in 1896. Outcrop consists of magnetic and brown iron ore in andesite. The iron ore is of excellent quality. Under the oxidised cap, massive pyrrhotite (magnetic pyrites) occur containing a little copper pyrites. The leaching out of the copper from the outcrop has been very thorough, and nearly as complete in the underlying magnetic pyrites. An assay of a selected sample of the latter yielded only 0·45 per cent. of copper, whilst below this level a mixed sample of pyrrhotite and chalcopyrite yielded 12·68 per cent.

As work had ceased when the Writer visited this mine in 1898, an inspection of the lower levels was not feasible. It is reported by Mr. J. Russell, of Blayney, that the two shafts are 75 and 105 feet respectively. In the former a crosscut has been extended 9 feet, and in the latter (at 50 feet level) 53 feet in lodestuff. The ore consists of a mixture of copper and magnetic iron pyrites, averaging about 7 per cent. copper. At the bottom of the 105-foot shaft a crosscut has been driven 13 feet, also in lodestuff. 15 tons 18 cwt. of ore from this mine, treated at the English and Australian Co.'s works, Waratah, yielded 5¼ per cent. of copper; gold, about 3 dwt.; and silver, 3 oz. per ton.

Sugarloaf, B., Canowindra Dn., Parish Malongulli, County Bathurst, near the Belubula River, on Cliefden Station.—The late Mr. W. M. Rothery, owner of this station, many years ago discovered a small, loose specimen of native copper close by a small creek. Later the lode was discovered. About three years ago arrangements to test it were made with the late Marmaduke Constable, and a shallow shaft and open-cut were sunk. Near the surface some fine specimens of native copper and cuprite were revealed by a blast. The country consists of highly-altered sedimentary rocks, close to the junction of hornblende porphyry. Superficial copper stainings marked the rock raised during operations; but nothing payable was discovered so far as these proceeded. A rough, rocky outcrop occurs, extending southerly, in which ferruginous bunches occur with stains of copper carbonates. This outcrop could be well tested by tunnel.

Summer's Copper Mine, B., Carcoar Dn., three miles south from Carcoar, on the Coomba Road, on the west side of Coombing Creek, Parish Summers, County Bathurst.—Mr. D. Milne, in October, 1896 (Pros. Papers 97-1,800), reported that the lode has a thickness of about 3 feet, with a gossan outcrop. Strike, north-west and south-east; dip, nearly vertical. The ores consist of carbonates, black and yellow ore, but rather dreggy. At 105 feet the lode appears to be making stronger. Aid granted to continue prospecting. At 155 feet the thickness was 3 to 4 feet. 5 tons sent to a smelting works yielded 11½ per cent. of copper.

Summer Hill Copper Mine, B., Rockley Dn., Parish Rockley, County Georgiana.—One of the earliest copper-mines opened in the Colony. According to Mr. James Ranken, of Bathurst, work was in progress here as early as 1847. In the following year a company was formed in Bathurst to work this property. An extract from the prospectus of the Bathurst Copper-mining Company, published in the *Bathurst Advocate*, of the 30th December, 1848, is embodied in the introductory portion of this work.

In April, 1851, Mr. S. Stutchbury examined the mine, and reported as follows:—"The rocks or strata in which the mining is carried on are for the most part mica and grindstone slates. The strike or level line is west of south and east of north. The workings consist of three shafts—the Gilmandyke, Clymo's, and the present working shaft. The sinkings are on two lodes, parallel to each other. The ores which form the bulk for smelting are pyritic, viz., yellow sulphuret of copper, arsenical sulphuret of copper, and domeykite (?) of Haidinger. There are other varieties in small quantities. On the spoil-heaps may be seen some very beautiful sulphates, formed by decomposition of the sulphides by exposure to the atmosphere. At the bank of the eastern shaft there is a large heap of ore which, from its appearance, I take to be domeykite, or arsenical sulphuret of copper—a very rich ore. This has been thrown out as waste, under the impression that it was iron pyrites—"mundic." There is also much valuable ore on the spoil-heaps and underground in one of the vugs. The experiment of smelting with green timber is in a fair way of being successfully proved. Although working under the disadvantages of an ill-constructed, half worn-out air-furnace, the produce of the first process was encouraging. The mine, with it present prospects, with care in the management, there is good reason to believe, might remunerate the adventure, although I do not think, without further discoveries, that it will ever be a first-class mine." Mr. Stutchbury's remark as to the good ore discarded in the spoil-heaps and fillings is significant of the character of the mining carried on.

In the *Mining Journal*, London, 1854, vol. xxiv, p. 264, reference is made to this mine. Four shafts, from 100 to 300 feet deep, and numerous levels are mentioned, and the erection of a furnace recorded.

Mr. H. Clements, son of the original owner of the Summerhill Estate, informed the Writer that the mine was discovered by a stonemason named Rex, who was working the soapstone in which the first indications of copper were found on the Gilmandyke Creek, about a mile from its junction with the Campbell River. This first vein was about 2 feet thick, in hard rock. It was sunk upon for about 90 feet, but was abandoned for a more promising lode about a quarter of a mile distant. The second lode was opened by two shafts and an adit for about 300 feet or more. The lode consisted of yellow sulphide, from 4 to 6 feet in thickness, estimated to yield 10 per cent. dressed. Mr. Clements states that the smelting process on the ground consisted of heap-roasting and reverberatory smelting; but, judging from the frequent occurrence of prills of metallic copper in the slag, the latter was badly performed. Probably not more than 20 tons of copper were dispatched from the mine. Operations ceased upon the discovery of gold, in 1851, arrangements being made by the company for suspension of work for a year. Operations were subsequently, renewed and continued until 1858. After the company finally abandoned the property, work was carried on for a few months by a Mr. Peck. No particulars are available of the output after the renewal of work. Very little indeed was to be seen for the capital expended.

In $\frac{1883}{\text{p. }126}$ Mr. Slee reported that a shaft had been sunk about half a mile north of the old Summerhill Mine, on a chute of good ore, 1 foot thick, between well-defined walls. A large outcrop of gossan occurs further up the hill.

In $\frac{1897}{\text{p. }72}$ the lodes were again being tried. Ore to the value of £500 is reported to have been sent away; 11 tons 4 cwt. of ore, picked from the old heaps, yielded 11¼ per cent. of copper at the English and Australian Company's Works at Waratah.

Sunny Corner, B., Mitchell, Dn., Parish Castleton, County Wynyard.—Apparently the first official mention of copper at Sunny Corner is that contained in the Annual Report of the Department of Mines for 1876, p. 78, wherein the Mining Registrar states that the copper mines at Sunny Corner were at a standstill. The ore had been taken to the Bowenfells Smelting Works, but had not paid expenses.

The mines at Sunny Corner were first worked exclusively for gold; but about 1881, Mr. H. Y. L. Brown sampled the lodes, and found that their principal value was in silver. Several companies were shortly afterwards formed, and blast furnaces erected. The first—a Pacific Smelter—was started in August, 1884. Whilst the kindly oxidised ores were abundant, smelting operations were successfully maintained. When, however, these were exhausted, great difficulties were encountered in treating the lower-grade refractory sulphides beneath, which consisted of a mixture of sulphides of iron, zinc, lead, copper, arsenic, antimony, &c. Operations were, however, carried on until the heavy fall in silver value, which banished any hope of profitable working under existing conditions.

All the Sunny Corner lodes carry more or less copper which, in smelting, is obtained as matte:—

In $\frac{1888}{\text{p. }59}$ 24,972 tons of ore from the Sunny Corner Proprietary Mine yielded 201 tons of lead, 300 tons of copper, and 1,256 tons of matte, containing 319,324 oz. of silver and 2,300 oz. of gold.

In 1890 the Phœnix Mine passed into the hands of the well-known copper smelter, Mr. Lewis Lloyd. 900 tons of cupriferous ore were raised and despatched to his Eskbank Smelting Works.

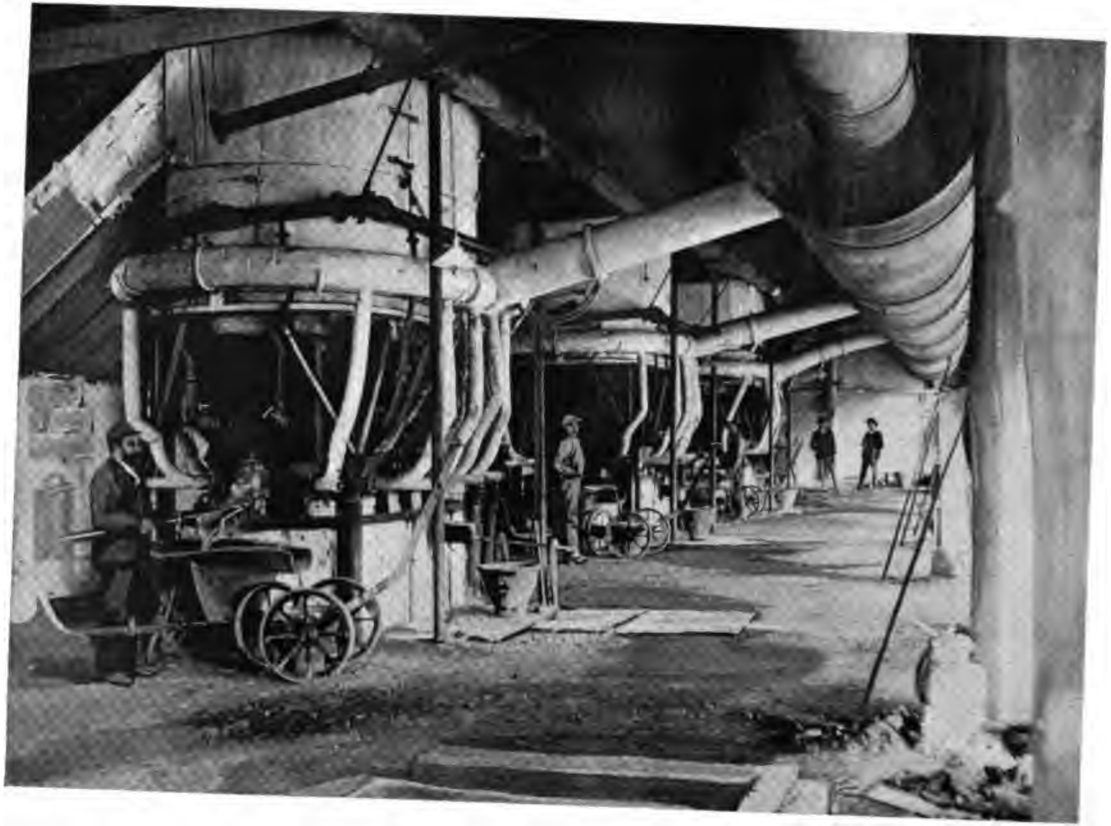
In $\frac{1891}{369}$ the Nevada Mine produced 110 tons of copper matte from 680 tons of ore smelted at the mine.

The Sunny Corner Proprietary produced 344 tons of copper from 34,046 tons of silver and gold ore treated during the year, and 77 tons in 1892.

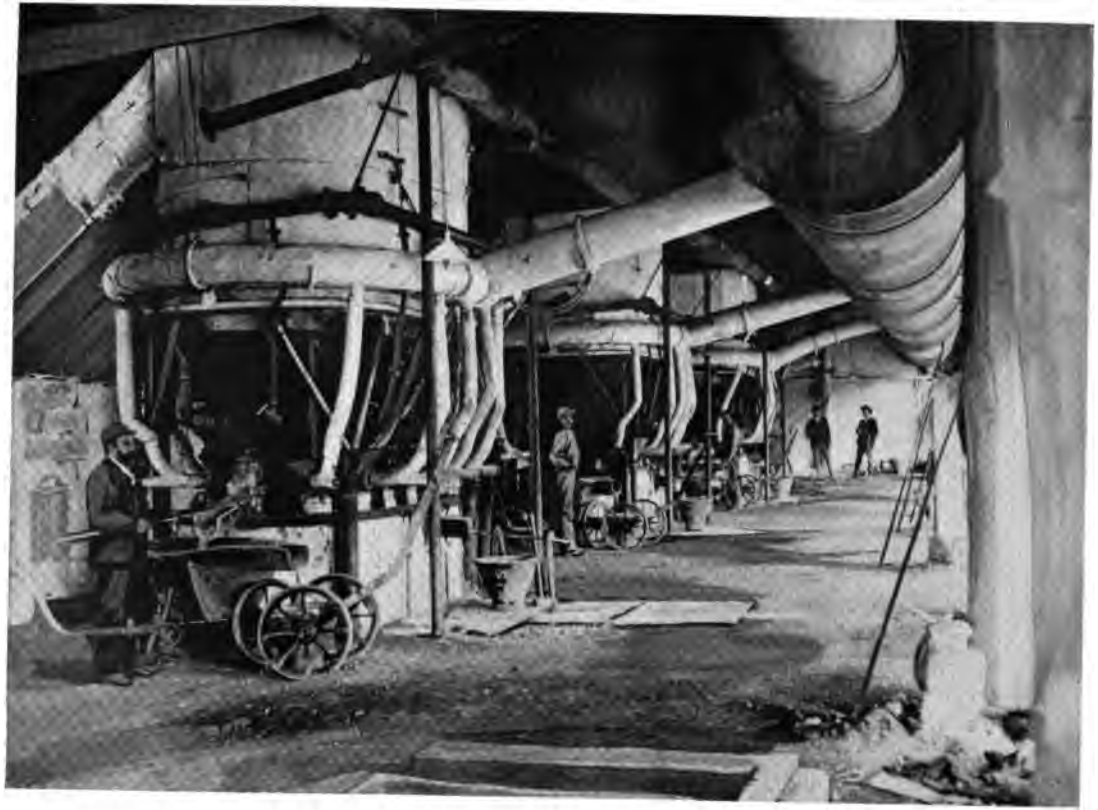
Between 1888 and 1895 (inclusive) the Sunny Corner Company produced, according to its shipping register—6,162 tons 10 cwt. 3 qrs. 23 lb. of matte, containing 1,109·25 tons of copper; 10,752 oz. of gold, and 1,361,676 oz. of silver. The Company paid fifteen dividends, amounting to £91,200, equal to

SUNNY CORNER SMELTING WORKS.

(Blast Furnaces during operations.)

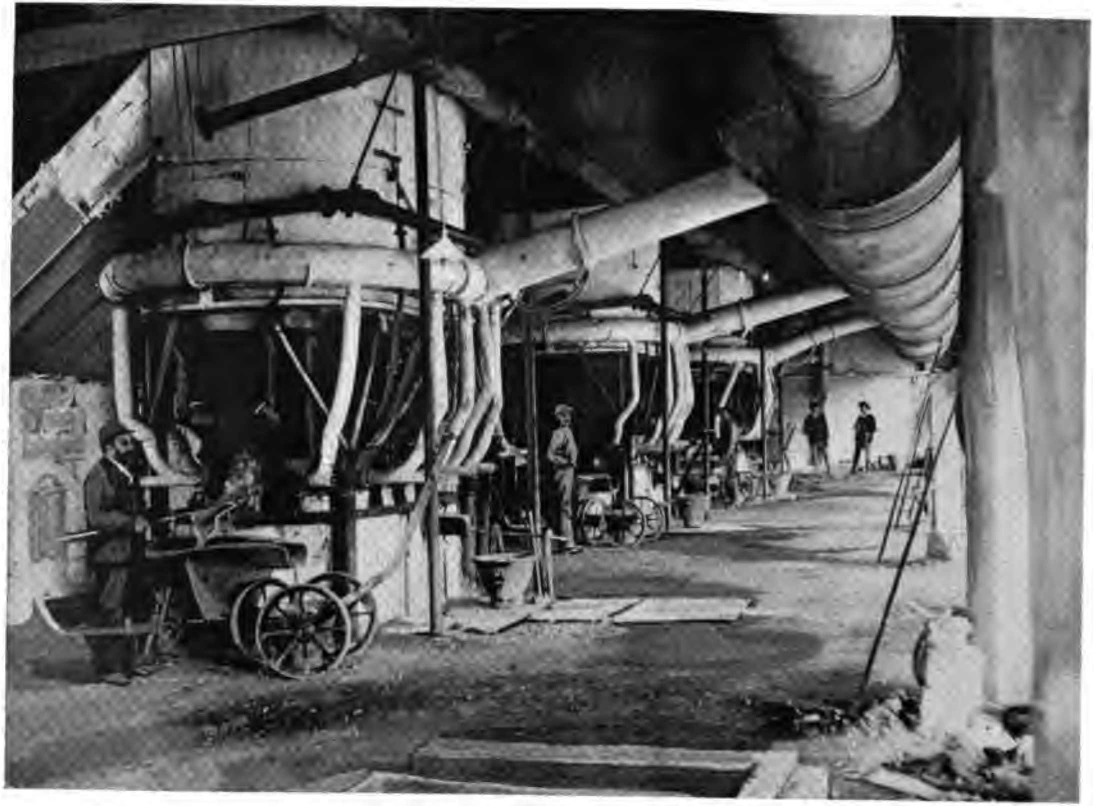


Sunny Corner Smelting Works.
(Blast Furnaces during operations.)

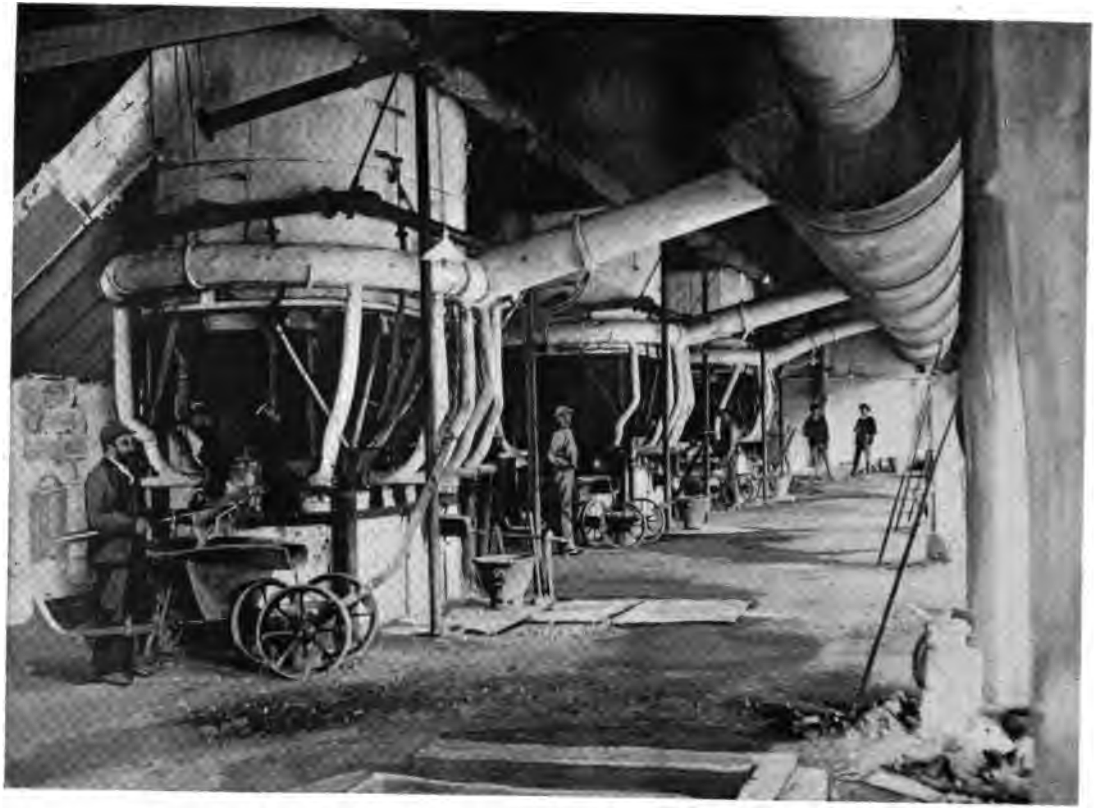


Sunny Corner Smelting Works.

(Blast Furnaces during operations.)



Sunny Corner Smelting Works.
(Blast Furnaces during operations.)



SUNNY CORNER SMELTING WORKS.
(Blast Furnaces during operations.)

28s. 6d. per each £1 share. After the Company ceased operations smelting was carried on by Mr. J. K. Charlston until the serious fall in the price of silver. According to Mr. Charlston's books, the average contents of the ores smelted has been—" Copper, 0·79 per cent.; silver, 7 oz. 8 dwt. 13·6 grs. per ton; gold, 1 dwt. 16·7 grs." The total cost of production, including rent of leases and additions to plant, amounted to 29s. 1d. per ton of ore.

Attention is now being directed to the Nevada Mine, which is reported to contain a fair proportion of copper, which, together with its gold and silver contents and siliceous gangue, renders it serviceable for fluxing copper matte, provided the cost of transport is not excessive. The following analyses were made from a sample selected by the late Government Geologist, Mr. C. S. Wilkinson.—(Annual Report, 1886, p. 140):—

	No. 1.	No. 2.
Oxide of iron and alumina	24·18	26·31
Insoluble siliceous matter	46·63	51·02
Lead	9·34	6·25
Copper	5·06	4·02
Bismuth	·88	trace.
Antimony	·43	,,
Arsenic	·90	,,
Sulphur	12·42	9·32
Manganese	trace.	trace.
Chromium	,,	,,
Undetermined, loss, &c.	·16	4·08
	100·00	100·00

Sunnyside Copper and Silver Mine, P. & U., Hillgrove Dn., Hall's Peak, Chandler River, Parish Tiara, County Sandon, about twenty-two miles by road from Hillgrove.—An aided prospecting party discovered loose specimens of argentiferous copper ore at this site, but failed to locate their source. Later Messrs. Keys Bros., of Hillgrove, after a systematic search, were successful in doing so In 1897, shortly after the discovery, Mr. J. B. Jaquet visited the mine, and sampled about 3 tons of ore which had been collected, the outcrop being at the time covered with loose shingle and *debris*, owing to the steepness of the slope on which it occurs. The assay results ranged from 39·38 to 47·51 per cent. of copper, and 10 to 13 oz. 13 dwt. 6 grs. of silver per ton. In March, 1898, the Writer also visited the scene of operations in connection with an application for prospecting aid, which was subsequently granted. The copper lodes occur as contact deposits at the junction of massive intrusive quartz felsite with slate and quartzite. Since Mr. Jaquet's inspection, two additional outcrops have been discovered on the river bank about 150 yards north of the first discovery. These average from 6 inches to 2 feet in thickness so far as exposed. Strike N. 80° W., dip N. 10° E. at 65°. The two latter occur about 15 feet apart.

The ore in the first lode consists of rich yellow sulphides, superficially coated with carbonates. In the second and third lodes the quality is depreciated by the presence of zinc in considerable proportion. At the surface the ore consists of blue and green carbonates, red oxide, and native copper; a few feet below, at the river level, yellow sulphides appear, mixed with zinc and lead sulphides. Under aid the shaft has been deepened to 50 feet, and a drive into the ridge was being extended from that level, the prospects being good.

The following assays were made of samples selected by the writer :—

No. 2 lode—(Carbonate and oxide, copper, pyrites, &c.).

$\frac{742}{98}$—Metallic	copper	22·59	per cent.
,,	zinc	4·57	,,
,,	lead	7·48	,,
,,	silver	5 oz. 1 dwt. 6 grs.	per ton.
,,	gold	nil.	

No. 3 lode—(Mixed sulphide ore).

$\frac{751}{98}$—Metallic	copper	14·32	per cent.
,,	zinc	16·04	,,
,,	lead	10·07	,,
,,	silver	2 oz. 3 dwt. 13 grs.	per ton.
,,	gold	nil.	

No. 3 lode has been opened by tunnel for 70 feet under aid; prospects reported good.

The Sunnyside lodes are situated on the southern bank of the Chandler River, which runs in a precipitous valley—over 2,000 feet in depth. If payable ore is proved to occur in workable quantity, a cable tramway, after the style of those in use at Hillgrove, will be necessary for transport in and out of the valley.*

Stuart Town, T. & T., Ironbarks Dn.—In the *Australian Mining Standard*, 27th May, 1898, a copper-lode is reported as being worked near Stuart Town; a shaft of 40 feet having exposed a lode of grey ore.

Talbingo Copper-mine, T. & A., Kiandra Dn.—The manager of this mine, Mr. A. Reichmann, under date 30th May, 1893, states that no stoping had then been done. From the shafts and levels about 44 tons of sulphide ore obtained, of an average value of 30 per cent. 18 tons 2 cwt. 2 qrs. 27 lb. sent to the Smelting Company of Australia's Works, Dapto, yielded 5 tons 8 cwt. 3 qr. 5 lb. of copper—equivalent to about 30 per cent.

Tarrlla Consols Mine.—(*See* Nuntherungie.)

The Caroline Copper-mine, L., Trundle Dn., about twelve miles west of Dandaloo, towards Woodlands.—Opened about 1888 to a depth of 140 feet. This mine was taken up again in 1898 by a Cobar syndicate, who supplied the following particulars through Mr. W. Gillard, of Cobar, under date of 7th September:—

"We thoroughly overhauled the surface of the mine, and find that there are three shafts—one supposed to be 140 feet deep; this shaft is 8 feet x 4 feet. The next shaft is supposed to be 50 feet deep. The other shaft is 14 feet deep. The 140-foot shaft is on the eastern side of the lode. The 50 feet is on the lode, which is 3 feet wide at the bottom of the shaft, containing very good carbonate ore. The lode strikes north-westerly in a 40-acre block. The net profit on 6 tons 14 cwt. of ore sold in March was £36 7s. 6d. The next parcel, of 6 tons, treated in May, returned a net profit of £27 4s. (sold to the Great Cobar Syndicate). The ore will average above 14 per cent. of copper. The amount expended on the mine was about £200. Mineral lease granted on 11th May, 1898, to W. Meriel and W. Rowe."

The Moir Copper-mine., A., Broken Hill Dn.—The *Australian Mining Standard*, 8th December, 1898, contains a reference to this otherwise unrecorded mine:—"The Moir Copper Mine, off the Silverton tramway-line,

* This property is now being further prospected by a syndicate under a purchasing option. The following parcels of ore have been recently treated at the English and Australian Smelting Works at Waratah:—1½ tons from No. 1 lode yielded 14 per cent. copper, 10 per cent. of lead, and 11 oz. of silver, and 2 dwt. of gold per ton. Two and a half tons from the first discovery yielded 35 per cent. of copper, 16 oz. of silver, and 2 dwt. of gold per ton.

11 miles from Broken Hill, is being worked by a small proprietary, with encouraging results. Carbonates and grey ore exposed at the 70 and 100 feet levels."

Tinby Hill, T. & T., Ironbarks Dn., about one mile northerly from Yeowal and about four from the Goodrich Copper Mine.—In the same belt of granite country as the latter, copper ore of poor quality has been prospected at Tinby Hill. On the hill and on its slopes stains of copper carbonates occur freely distributed, but rarely forming more than mere colourations in the joints and cracks of the granite. Under Government aid a shaft was sunk about 60 feet in a large body of quartz, stained with carbonates, in which a little gold occurs, but not in payable quantity. More recently a syndicate has been prospecting on the top of the low hill, along a small joint which carries copper pyrites, concentrated in ¼ to ½ inch skins on the faces of the joint. Little quartz shows at this point, but farther south at the end of the hill, old workings reveal a quartz reef about 10 inches thick, lightly copper-stained. A short distance west, another line of jointing shows faint stains of copper. The strike of both joints is about N. 10° W. A shaft has been sunk 28 feet on the first mentioned with hard country at bottom. As copper lodes, these are of no value, and the gold contents are not in payable quantities.

Touga Copper-mine, S., Yalwal Dn., Parish Touga, County St. Vincent, about ten miles from Nerriga, in a northerly direction.—The first record of copper-ore in this locality appears in the *Parliamentary Votes and Proceedings*, 1872, vol. ii, p. 1021, in the form of a petition *re* a copper lode on the west side of Togra (?) Creek, Braidwood District, north and south of the crossing-place at Querera Station, which, petitioners averred, had been wrongfully taken up by others who had learned of its existence from one of the discoverers.

In $\frac{1889}{p.\ 134}$ Mr. J. B. Jaquet visited the locality, and reported as follows:—"The geological formations represented are horizontally bedded sandstone belonging to the Devonian or Upper Marine Series, and much indurated slates and quartzites of Silurian age. The copper lodes are confined to the slates, &c. The outcrop of a copper lode has been exposed for a distance of 36 feet, at a point distant about 100 yards below the junction of Touga and Quera Creeks. The lode is about 2 ft. 6 in. thick. It does not appear to have defined walls, but, like many other deposits of this metal, seems to consist of a country more or less impregnated with quartz and copper pyrites.

"About 200 yards north of the lode last described, another one has been discovered, and traced for several chains upon the surface. It is about 1 foot wide. A picked sample yielded 18·16 per cent. of copper, and silver at the rate of 1 oz. 12 dwt. per ton.

"A little south of the junction of the two creeks the outcrop of a copper lode can be seen running up the precipitous bank of Touga Creek."

Mr. J. Donohue, who worked in the mine, states that the prospecting shaft was sunk 40 feet vertical and 40 feet on the underlay, and a level driven 80 feet on the course of the lode. No stoping was done. The only ore raised was from the sinking and driving. The copper deposits were very patchy. The ore was chiefly grey ore. A little native copper was obtained from the shaft.

Trisser Copper Mine, B., Rockley Dn., half a mile east of Essington Mine.—haft sunk 80 feet. A small quantity of ore obtained.

Trunkey District, B., Trunkey Dn.—Two copper lodes occur near Trunkey—one near Kempfield (which see) and the other near Bombah. The former was worked off-and-on, but not with much success. The latter was equally unproductive.

Copper ores are also reported at Scrubby Rush, Sounding Rock, and Tiger's Hut. A sample from the latter, $\frac{4881}{97}$ yielded from 12 to 14·69 per cent. of copper.

Tuglow District, B., Oberon Dn., County Westmoreland.—For some years copper ores have been known to occur in this district, but little practical effort was made to develop them until quite recently. Mr. W. J. Bouchier, of Clover Hills, near Tuglow, who is working a lode in portion 52, parish Banshea, supplied the following information, under date of May, 1898:—"The lode in portion 52 has a thickness of about 5 feet. Two shafts have been sunk 30 and 45 feet. From one of these, 36 tons of ore were extracted for an average yield of 14 per cent. of copper, 10 per cent. of lead, and 5 oz. of silver, and 2 dwt. gold per ton. The outcrop is gossan, but at the depths quoted sulphides of copper and lead are encountered.

Mr. H. Hooke, Inspector of Mines, who recently visited Tuglow, states that Bouchier and party have sunk to a depth of 60 feet, on what appears to be a true fissure vein, averaging 3 feet in thickness, and containing ore rich in copper, and which has also yielded as high as 17 dwt. of gold per ton.

The lode has a N. and S. strike in slate country, and dips somewhat flatly towards the west. Walls well defined.

About half-a-mile south of this is Cunningham and party's claim, in which a vertical shaft is being sunk to intersect a well-defined vein.

Still further south and within a quarter of a mile is Cotton and Fraser's claim. Their main shaft has been sunk to a depth of 45 feet, on a contact lode between a diorite dyke and the slate country which is tilted at a high angle. Strike of lode N. and S., dip easterly. Bunches of good grade ore occur at the junction and extend for some feet into the slate.

Under date March 15th, 1899, Mr. McLeay, Warden's Clerk, Burraga, writes: "That at 60 feet water was getting troublesome. A sample of copper pyrites with galena and zinc blende forwarded by the Warden's Clerk yielded ($\frac{224}{99}$)—copper, 10·73 per cent.; lead, 23·02 per cent.; zinc, 13·10 per cent.; and silver, 9 oz. 1 dwt. 20 grs. per ton."

Fourteen tons from Cotton and Fraser's mine, treated at the Smelting Company of Australia's Works, Dapto, returned 9 per cent. of copper and 16 dwt. 22 grs. of gold per ton, the ore being unpicked. Thirty tons were ready for despatch. Native copper appears along the footwall of the lode.

The cupriferous belt at Tuglow can be traced for some miles, and limestone occurs in conjunction.

The sale of Bouchier's and Cotton's mines is being negotiated.

Tumbarumba Division, T. & A.—The Warden reports the occurrence of copper ores in the Parishes of Coppabella and Yarrara, County of Goulburn, but not in payable quantities. A sample from Upper Burra Creek, near Tumbarumba, yielded ($\frac{2678}{99}$), copper 25·55 per cent. and 3 oz. 18 dwt. 9 grs. of silver and 6 dwt. 12 grs. of gold per ton.

Upper Bingara.—(*See* Harrison's Mine.)

Vychan Copper Mine, L., Forbes Dn., Portion 81, Parish Wise, County Ashburnham, twenty miles east of Forbes, eight miles from the Lachlan River, and fourteen miles from Cookamidgera Railway Station.—Copper was discovered in the adjoining Eurow Mine—300 feet distant—by a member of D. Sloan's family about 1881. The site was secured by mineral conditional purchase, but was abandoned after three shafts had been sunk. In 1889, 56 tons 9 cwt. from this lode, forwarded by Mr. A. Lockart to the English and Australian Smelting Works, Waratah, yielded 17½ per cent. of copper.

The country consists of highly-crushed and altered sedimentary rocks. The lode strikes N. 30° W., and dips west.

The Vychan Mine was taken up by the present owner, Mr. F. Clayton, as a mineral lease of 40 acres in September, 1897. The main shaft has been continued to the 150-feet level and the north shaft to 120 feet. Levels connect the shafts at 30, 109, and 150 feet. The sulphuret ores begin to appear at about 120 feet from surface. Above this level oxidised ores occur in bunches. The lode varies from 1 to 8 feet in thickness, averaging about 2 feet. Both the oxidised and sulphuret ores are of excellent quality. To the date of inspection in February, 1899, about 50 tons of ore had been dispatched to the Smelting Company of Australia, Limited, Dapto, the copper contents of which ranged from 17·7 to 25·3 per cent.; silver, from 4 to 10 oz.; and gold, 2 to 5 dwt. 14 grs. per ton.

Since the date mentioned, the following consignments were treated at the above works for yields shown in the accompanying table, which will also reveal the character of the ores:—

Weight.	Copper.	Silica.	Gold, per ton.	Silver, per ton.	Nature of the Ore.
	per cent.	per cent.	dwt. gr.	oz. dwt. gr.	
53 bags (?)	20·5	20·2	1 19	3 2 9	1st carbonates.
22 „ (?)	12·5	20·6	4 14	1 19 14	2nd „
10 „ (?)	12·4	26·8	4 4	2 3 14	3rd „
tons cwt.					
4 17	21·7	......	3 0	....	1st „
1 1	16·1	......	3 4	....	2nd „ (screenings).
2 16	16·3	......	1 19	....	Fines „ „
2 4	23·3	......	4 0	....	1st „
5 10	8·5	......	3 19	....	4th „
6 17	9·6	......	2 14	....	Sulphides from 150-foot level.
2 6	23·9	......	2 4	....	Carbonates.
1 7	17·5	......	2 19	....	Fines „
8 5	11·0	......	2 14	....	Sulphides.
6 0	13·0	......	3 0	....	1st sulphides.

In driving between the north and south shafts at the 150-feet level, the main body of sulphides was struck near the north shaft, at an angle which carries it about 7 feet west of the south shaft, from which the level started, and accounts for the blank country at the latter. The sulphides are solid and 6 feet wide at the point of intersection.

Prospecting northerly from the 120-foot level in the north shaft. After 50 feet of blank country, copper stains and a little copper glance is making in the drive. (For particulars of the adjoining mine, south on the same lode, *see* Eurow Mine.)

Walcha District, P. & U., Walcha Dn.—Copper ores are reported at the following localities in this division:—

Walcha Creek, near Nowendoc.

Blue Mountain Creek, nineteen miles north-east of Walcha.

Jones's Reef.—From here a sample ($\frac{428}{97}$) yielded—copper 10·97 per cent., and silver 13 oz. per ton.

In May, 1873, the English and Australian Smelting Company, Waratah, received two consignments of ore from this district, probably from one of these localities, which yielded as follows:—

9 tons	11 cwt.,	21½ per cent.	of copper.
1 „	5 „	22½ „	„

Walker's Hill, C., Bobadah Dn., one mile north of Walker's Hill Homestead and sixteen miles from Bobadah. Copper ore occurs here in slate and sandstone. Aid was granted from the Prospecting Vote to sink 65 feet and drive 40 feet on a number of leaders from 1 to 4 inches thick, similar to those occurring in an old shaft about 110 feet south. The results obtained under aid were not encouraging, no improvement in the ore veins being manifest.

Wallah Wallah Copper Mine, S., Yass Dn., Parish Rugby, County King.—Opened about 1846, according to Mr. J. K. Hume. Mr. W. Anderson $\left(\frac{1}{p}\frac{8}{2}\frac{9}{6}\frac{1}{8}\right)$ reported that this mine was opened over forty years prior to his visit to the locality, some good ore being obtained from it. Mr. J. B. Jaquet, who accompanied Mr. Anderson, states that the lode occurs in granite about 1½ mile from the junction with slates in the Parish of Ware. It has a general north and south strike. The outcrop can be traced for a considerable distance, its width being about 4 feet. A good deal of carbonate ore can be seen where the lode is exposed.

Mr. I. Stevenson, of Burrowa, states that no ore was smelted or sent from the mine during the early workings, but that it was stacked on the surface. Many years after, it was despatched to smelting works, but the result is not known.

Wambrook Station, T. & A. Cooma Dn., about eighteen miles westerly from Cooma. On this station, about five miles north-west of the Gygederick Copper Mine, a copper lode was opened about 1878. Mr. G. F. Litchfield, of Matong, states that it consists of quartz, with malachite and chalcopyrite, striking east and west in granite. The outcrop was not regarded as payable, but some rich specimens were obtained from the lode, which averaged about 3 feet in thickness.

Waroo Ridge, B., Cargo Dn.—Referring to a creek which empties into the Conomodine Creek, one of the tributaries from the Canoblas to the Belubula River, Mr. Stutchbury, in 1851, stated "that the slate is traversed by trap dykes and elvan courses, and is very likely country for copper; specimens of which are recorded as having been found upon the ranges, especially upon a ridge named "Waroo."

Waugoola Creek Copper Mine, B., Cowra Division.—This mine (which was first opened some years ago), is now being reworked. Mr. D. Milne, Inspector of Mines, states that at the 104 feet level the lode is 6 inches thick in the shaft, but occasionally it increases to 3 feet in bunches. The following parcels of ore have been dispatched to the Lithgow Smelting works:—

30 tons	realised	£600	net.
7	„	98	„
7	„	114	„
44 tons	realised	£812	net, equal to £18 9s. 2d. per ton.

About half a mile south of Waugoola Creek, on the travelling stock reserve, a large quartz reef, about 2 feet thick, strikes north and south through slate country, and carries stains of copper carbonates, which also occur in the walls.

Wellington District, M., Wellington Dn.—The late Government Geologist, Mr. C. S. Wilkinson, in $\frac{1876}{p.\,60}$ reported that the formations at Wellington consist of a thick series of sandstones, shales, conglomerates, and limestones, traversed in places by greenstone dykes, provisionally classed as Upper Silurian. The diorite dykes are in some places traversed by quartz reefs containing gray sulphide and carbonates of copper.

In $\frac{1888}{p.\,59}$ the Mining Registrar reported that 300 tons of ore had been smelted for a yield of 40 tons of copper, but no particulars of localities are given.

Copper ores are reported in the following places:—

Fittes Mine, about twelve miles from Wellington; working in 1876. An assay reported $\frac{1880}{p\,135}$ of copper glance and pyrites yielded 10·04 per cent. of copper, and 7 oz. 14 dwt. 10 grs. of silver per ton.

Weandre Creek, parish Three Brothers. Copper reported present in most of the reefs of this locality.

Wellbank—

The Springs Railway Station.

Lindberg's Mine, Wellington Common.

Apsley " " "

In $\frac{1882}{p.\,72}$ a small smelting furnace was erected near Wellington at a cost of £150, and ores from the Apsley and Lindburg's Mines were tested with poor results.

In 1898, the Warden reported that applications had been lodged for copper lands at the following places in his district, but that little real work had resulted:—

Wellington Common.

Ten miles from Wellington.

Galwadgery Creek.

Ponto, near Wellington.

Garry Owen—carbonate ore assaying 3 to 6 per cent.

Newrea.

Three Mile Flat—assaying 13 per cent.

Goolma Creek.

Kadumble Range.

Kaiser Mine, twelve miles from Wellington.—In $\frac{1877}{p.\,123}$ the Mining Registrar reported that the lode stuff from this mine passed through the battery contained such a large percentage of copper that it was reserved for further treatment. Assays $\frac{222 \text{ and } 222}{80}$ yielded 21·5 and 42·35 per cent. of copper.

Apsley Mine—close to Apsley Platform, about two miles east of Wellington.—Ore recently taken from this mine (in andesite) was dressed and dispatched to Lloyd's Lithgow Smelting Works by W. P. Mitchell, the returns from 4 tons 17 cwt. being—copper, 7·9 per cent.; silver, 2 oz. and gold, 7 dwt. 13 grs. per ton.

Mount Bodangora Mine, Mineral Lease, 5, Parish Tenandra, County Lincoln, about twelve miles from Wellington; country rock andesite.—Several shallow shafts sunk, revealing traces of copper carbonates only; nothing defined. Native copper struck in first working shaft at about 20 feet. No walls visible—copper occurring partly in films in joint faces, and partly disseminated through the andesite, which is hard and unpromising. A sample of copper-stained quartz, partly jasperoid—selected by the Writer—was tested for gold, but none was detected. Silver occurred at the rate of 2 oz. 5 dwt. 17 grs. per ton.

In the andesitic rocks of Wellington, Blayney, and Carcoar, native copper is frequently found in small isolated pellets and in thin veins. The weathering and decomposition of the metal in the exposed outcrops of the andesite has stained it in many places, giving rise to prospecting for lodes—but none have eventuated in the solid rock

Wertego Copper Mines—(*See* Nuntherungie.)

Wilbertree, M. Mudgee Dn.—In the latter part of 1896, a newly discovered copper lode in R. Atkinson's land at Wilbertree, nine miles north-west of Mudgee, was opened up. A shaft was sunk 60 feet which cut through the lode at 13 feet. The outcrop reported from 12 to 15 feet wide, showing carbonates. Work soon abandoned without any tangible results being obtained.

Willandale Creek, B., Blayney Dn.—Copper ore reported on this creek three miles north-west from Blayney.

Williams Copper Mine—(*See* Great Western.)

Willi Willi Copper and Silver Mine, H. & M. Kempsey Dn., situated about seven chains south of south-west corner of Portion 17, Parish Panton, County Dudley.—

Formation, Permo-Carboniferous limestones, altered claystones, and sandstones, with intrusive diorite. (?) Rich bunches of copper carbonates were discovered near the junction of the rocks mentioned with the igneous intrusive rock. Masses of garnet have resulted from the contact of the latter with the limestone.

Copper ore was discovered in this locality by H. H. Mansfield about 1893. At the first site—in limestone—aid was granted to sink 80 feet, and drive 50 feet, but the surface ore was found not to extend below 26 feet. Four tons sent to Wallaroo Smelting Works, South Australia, yielded 7 per cent. of copper and 73 oz. of silver per ton.

About 25 chains S. 80° E., a more promising outcrop was discovered at the junction of an intrusive dyke. A number of short tunnels were driven along the junction line, and a few tons of rich ore extracted from bunches in the lode.

Between the two outcrops a third occurs which has also been prospected under aid, but not with payable results.

The best results have been obtained, and the most favourable indications occur in the contact lode which has not been sufficiently tested, as the oxidised zone has not been pierced. The sulphides require proving before the real value of the deposit can be ascertained. A considerable amount of leaching has occurred in the oxidised cap. The character of the ore bunches found in the latter can best be judged from the following assay returns, made in 1894; the silver occurs in the form of chloride:—

Copper gossan,	No.	1717—	copper,	37·66 per cent;	silver,	163 oz.	3	dwt.	16	gr.	per ton.
Blue Carbonate	,,	1491	,,	29·28	,,	,,	23 ,,	3	,,	9 ,,	,,
Carbonate	,,	2413	,,	36·94	,,	,,	107 ,,	7	,,	8 ,,	,,
,,	,,	2414	,,	49·67	,,	,,	118 ,,	2	,,	22 ,,	,,
,,	,,	2415	,,	16·15	,,	,,	46 ,,	1	,,	3 ,,	,,
,,	,,	3418	,,	31·71	,,	,,	283 ,,	15	,,	6 ,,	,,

Ten tons of ore from the tunnels sent to South Australia in 1894, yielded, according to Mr. R. Campbell, of Warneton, Macleay River, 15·75 per cent. of copper and 23 oz. of silver per ton.

Willow's Mine, N.E., Emmaville Dn, north side of Glen Creek, four miles from Tent Hill, six miles from Emmaville, and eighteen from the Deepwater Railway Station.—This mine occurs between the Little Plant Silver Mine and the Emerald Mine. The lode in it varies from 8 inches to 3 feet 6 inches in thickness, and is about 12 inches at the lowest level reached—70 feet.

5¼ tons yielded about 5½ per cent. of copper at the Smelting Company of Australia's Works, Dapto,

Wirlong Copper Mine, C., Nymagee Dn., about fourteen miles south-west of Nymagee, in the Parish of Priory Plains, County Mouramba.—Discovered in 1898 by Morris and Kelly, in porphyry, close to the junction of slate. At the time of inspection little ore was in view; but three small veins had been exposed at intervals for about 150 yards, on a N. 10° E. strike, and dipping S. 80° E. A shaft sunk between the veins to a depth of 58 feet cut one of them in a few feet and followed it to the depth mentioned. Fair specimens occur, but nothing defined was discovered at that date. Aid was granted to continue sinking and to crosscut to intersect the parallel veins.

Wiseman's Creek Copper Mine, B., Rockley Dn. (known also as North Wiseman's, and Eyrie South Mine), about twenty-two miles from Bathurst, and twelve from Brewongle Railway Station.—In October, 1873, the English and Australian Smelting Company, Newcastle, treated the following parcels of copper ore from Wiseman's Creek, which probably represent the first extracted:—

9 tons 2 cwt.; yield, copper 13 per cent.
4 „ 14 „ „ „ 10¼ „

The first official record is embodied in the *Mineral Statistics of New South Wales*, $\frac{1876}{\text{p. }92}$. In it the Wiseman's Creek Copper Mining Company was reported to be working a lode at Wiseman's Creek, striking N. 30° W., with a slight dip to the west. It had been proved to a depth of 120 feet, where it had a width of 20 feet. 700 tons of ore had been raised and 350 sold at an average of £7 per ton. Assays yielded from 9 to 17 per cent. of copper, an equal amount of lead, and traces of gold and silver. Fourteen men were employed.

In the Annual Report of the Department of Mines for the same year, pp. 142 and 145, assays by Professor Liversidge are published, viz.:—

Carbonate ores yielding, from 16 to 27 per cent. of copper.
Sulphides „ 9 to 10 „

The above were associated with zinc and quartz in a lode 18 feet wide; depth 100 feet.

In $\frac{1878}{\text{p. }77}$, the Mining Registrar reported that smelting works had just been commenced, and that the ore had been found to contain copper, lead, zinc, silver, and gold.

In $\frac{1877}{\text{p. }117}$, ore was being raised. In this year the mine was inspected by the late Government Geologist, Mr. C. S. Wilkinson, who reported as follows:—"The lode is in talcose schists, which dip S. 79° 45′ W. at 63°. It occupies the fissure of a fault, and strikes N. 15° W., and has a varying dip generally to the east. The ore occurs in bunches along the course of the fault and in offshoots from it. These bunches and shoots of ore, together with some veins of quartz, are of irregular thickness, being from 1 to 18 feet. The ore is of a very mixed character. It consists of green and blue carbonates, sulphides, and black oxide of copper, with the sulphides of lead (galena), zinc (blende), and iron and arsenical pyrites; occasionally a little native copper is met with. Occupying, as it does, the fissure of a fault, the lode will doubtless prove to be a permanent one in depth."

In $\frac{1878}{p.\,97}$, under the head of "North Wiseman's," the mine was reported in full work. The main shaft had reached 162 feet and the lode was being driven on at that level. 30 to 40 tons of ore per month were being raised of about 8 per cent. grade; twelve men employed.

In $\frac{1879}{p.\,69}$ work was continued up to November, £1,750 worth of copper ore being obtained.

In 1880 the mine was closed.

In $\frac{1884}{p.\,47}$ work was being carried on, but unremuneratively. Payable prospects of silver being obtained, a number of leases were taken up hereabouts.

In 1888 and 1889 a fresh attempt was made—by Messrs. E. A. Baker and Sons—to work the lode under the name of the Eyrie South Copper and Silver Mine; but the effort was unsuccessful, and the mine, which is on private land, has since remained idle. The ores, as already described, are of a very refractory nature, zinc sulphide being largely predominant—a feature of the lodes in this locality. A reverberatory furnace was erected but never used.

Wiseman and Party's Mine, A., Broken Hill Dn.—The Acting Warden, under date July, 1898, stated that this party sank 100 feet on a lode trending east and west, having a thickness of 2 feet. The ore is estimated to yield very high returns, but no particulars were given of the quantity available.

Woodlands.—(*See* Caroline Mine.)

Wood's Reef, P. & U., Tamworth Dn., two miles south of the village of Wood's Reef. Parish Wood's Reef, County Darling.—Mr. J. R. Godfrey, Inspector of Mines ($\frac{p.\,221}{98}$), reports that the lode strikes N. 30° W., and dips south-westerly in quartzite. Its thickness is about 6 feet. The ironstone and gossany cap is more or less stained with copper carbonates, and rich carbonate ore occurs at the south end.

A parcel of 2 tons 13 cwt. of ore from this lode, treated at the English and Australian Smelting Works, Waratah, yielded 14½ per cent. of copper.

Woodstock, B., Cowra Dn. (*see* Burley Jacky, Belmore, and Waugoola Mines).—Woodstock, on the Blayney-Cowra railway line, is situated in a belt of andesitic rock, which is more or less cupriferous. Also in the adjoining Carcoar and Blayney districts. A considerable amount of prospecting has been carried out in the neighbourhood of Woodstock, frequently occasioned by the superficial stainings on the andesite outcrops. These have often led to useless expenditure, as no defined ore bodies have been found in the solid rock, which owes its deceptive colouring to decomposition of sparingly distributed particles of metallic copper indigenous in the andesite. Near Sugarloaf Mountain, on Cliefden Station, native copper occurs in Smith and McGuiness's shaft, and also in Rothery's Mine near by. In the former instance the copper occurs in an amygdaloidal andesite, both in the solid and in the amygdules.

In addition to the mines mentioned, copper ores occur in the following localities:—Purcell's land, about two and a half miles northerly from Woodstock; opened in 1895 by two shafts 40 and 60 feet deep. Carbonates and grey sulphides occur, much mixed with the country, but no true lode was proved.

From Nobby's Mine, Woodstock, the Under Secretary for Mines reported $\frac{1892}{p.\,42}$, that 150 tons of ore were sold for £620.

In addition to the above lodes, the Writer has examined others at various times:—The Cowra Mine, at Bald Hills, about three and a half miles south-west; Russell and Party's, four miles south-west, which had an outcrop of about 4 inches and a thickness of 2 feet at 17 feet; strike north and south. Phœbe and Party's Mineral Lease 51, about five miles south-west of Woodstock, where a shaft had been sunk 70 feet on a lode consisting of quartz and clay with carbonate and oxide of copper; strike N. 60° W. Jones's Claim, south-east of Woodstock, vein 4 inches, consisting of carbonates and sulphide. T. Austin and Party's, half a mile north of Belmore Mine at the junction of sedimentary and intrusive rocks. Bartemote and Hudson's, Portion 71, Parish Kenilworth, County Bathurst; here shafts were sank twenty-five years ago in soft schistose slate, striking north and south, and carrying a little copper carbonates with quartz veins; also at Wood's Creek, four miles south of Woodstock. In Cooley's Estate, Westville, seven miles from Cowra, aid was granted to sink on a lode channel having well-defined walls. The slaty dig between the walls carries thin copper-bearing leaders. Aid granted for 100 feet of sinking.

Woolgarlo Mine, S., Yass Dn., Yass River, seventeen miles from Yass.—This mine is situated directly opposite the Good Hope Mine. Mr. Argyle McCullum states that several lodes of copper and lead occur on the Woolgarlo property of 1,248 acres; but beyond shallow surface work, nothing has been done to develop them. One lode of carbonate ore is reported to be 3 or 4 feet thick, and has been opened to 60 feet. The main lead (galena) lodes have no defined walls; copper stains occur in them. In 1870 a crushing and smelting plant was erected on this property; but being placed too close to the river bank, it was washed away in the first flood. The prospectus of the Woolgarlo Lead-mining Company (Limited) was issued in 16th March, 1867.

Wyangle, T. & A. Tumut, Dn., Parish Wyangle, County Buccleugh.—In Geary's private land copper ores in serpentine have been exposed in an open cut. Assay $\frac{2380}{96}$ yielded 13·64 per cent., and $\frac{4759}{97}$ 20·4 per cent. of copper, and 5 oz. 8 dwt. 21 gr. of silver per ton. A sample from Kiley's 50 feet shaft assayed $\frac{2744}{98}$ 12·30 per cent.

Yalwal, S., Yalwal Dn.—Mr. E. F. Pittman reported, $\frac{1882}{p.180}$, that on Dangera Creek, about four miles above the Yalwal gold workings, a lode occurs striking northerly, having a width of 4 feet. At surface blue and green carbonate stains and occasional patches of black oxide of copper occurred, but in a few feet in depth the lode passed into rather massive zinc blende and pyrites.*

Yarrogol Copper Mine, M., Wellington Dn., Portion 40, Parish Yarragol, County Bligh, about four miles from Dripstone Railway Station.—Originally opened about twenty years ago. Taken up again by Aaron and Party about five years later. A truck load of ore raised during the operations of the latter was sent by the present owners—the Woolaman Mining Syndicate—to Lloyd's Smelting Works, Lithgow, about 3½ tons being carbonates, and 2½ tons sulphides. The former realised 9 and the latter 6 per cent. of copper. The developments consist of a 30-feet shaft sunk by the first prospectors, and a 60-feet shaft sunk by the last at some distance from the former. A crosscut from the latter, however, failed to reach the lode. This caused some of the shareholders to abandon their interests, and caused the closing of the mine.

Yarrangobilly, T. & A., Kiandra Dn., Parish Yarrangobilly, County Buccleugh.—One of the well-known Yarrangobilly Limestone Caves bears the name of Copper Mine Cave, because of the proximity of a quartz-reef

* A company is being projected to open this deposit under the name of the Illawarra Main Copper Mining Company, Ld.

carrying a little copper ore; in fact, from Yarrangobilly Village to the Caves, a distance of about seven miles, copper ores occur, and numerous small prospecting holes have been sunk, but nothing of importance was proved.

Lower down Yarrangobilly Creek, about four miles above its junction with the Tumut River, Lobb's Hole Copper-mine is situated (which see).

Yellow Mountain, C., Bobadah Dn., M.L. 1, fifteen miles southerly from Bobadah.—At the north end of Yellow Mountain, which consists of quartz felsite or quartz porphyry, Byron Bros. discovered three outcrops of ferruginous carbonate of lead of very kindly appearance. In one of these a little copper ore occurs—red oxide, and traces of carbonate; but the chief value lies in silver and lead. The two principal deposits form bunches on the surface from 18 to 20 feet long, and 6 to 7 feet wide; beyond the bunches the lodes continue, but are thinner. The principal bunch, containing the copper ore, has been followed down 40 feet, where it is from 2 to 2 ft. 6 in. thick. There is every indication of the lode continuing to form lenticular bunches. Six tons of the ore sent to the Smelting Company of Australia's Works, Dapto, yielded 9 per cent. of copper, 45 per cent. of lead, and 33 oz. of silver and a few dwt of gold per ton. This bunch occurs in slate between quartz porphyry, the other in the porphyry.

Yeoval.—(*See* Goodrich.)

Geographical Distribution of Copper Ores in New South Wales in Mining Districts and Divisions. (*a*)

Note.—Names marked in this type * are the important working mines; those in this type † are prospecting or raising ores, and those in this type ‡ are those formerly worked.

Mining District.	Mining Division.	Copper Mine or Occurrence.
Albert	Broken Hill	*Mines* (*b*).—**Broken Hill Mines**; Balaklava;‡ War Dance; Purnamoota; Red Jacket; 12 miles from Broken Hill; Copper Blow; 8 miles N.W. of Corona; Gt. Barrier; Invincible; 11 miles S.W. of Broken Hill; Mt. Gipps; Mootwingee; Nuntherungie; Pinnacles; Wiseman and Party's. *Occurrences* (*c*).—Neighbourhood of Silverton; West of Umberumberka; Hornsby Range, 8 miles from Tarrawingee, etc.
	Milparinka	*Occurrences.*—Kooningbery Mountain, near Packsaddle; Mt. Arrowsmith.
	White Cliffs	*Occurrences.*—Black Mountain, Yungnulga.
Bathurst	Bathurst	*Mines.*—Glanmire; **Green Swamp**,† Northumberland. *Occurrences.*—Long Swamp; Dirty Swamp; Keloshiel.
	Blayney	*Mines.*—**Annandale**; **South Annandale**; Sugarloaf; **Wright & Osbornes**; Quigley's Hill. *Occurrences.*—Brown's Creek; Clausen's Property; Glasson's Property; Willandale Creek.

(*a*) The Divisions herein given are those most recently adopted by the Department of Mines, as shown on the accompanying map.
(*b*) Deposits worked or named.
(*c*) Unworked or unnamed.

Mining District.	Mining Division.	Copper Mine or Occurrence.
Bathurst	Burraga	*Mines.*—*BURRAGA;† South Burraga; Hockey's Mine; Stain and Party's.
	Canowindra	*Mines.*—BELMORE; Belubula; Smith & M'Guinness's; Sugarloaf Mountain; Copper Mine Creek. *Occurrences.*—Sugarloaf Mt.; Licking Holo Creek, etc.
	Carcoar	*Mines.*—COOMBING; SUMMER'S; Cathleen and Party's. *Occurrences.*—Kempfield Station; 4½ miles W. of Manduramah; Burnt Yards; 3 miles south of Carcoar, etc.
	Cargo	*Occurrences.*—Cargo and Ironclad Mines; Waroo Ridge.
	Cowra	*Mines.*—Cowra; BELMORE; Burley Jacky; Nobbys; Purcell's; Waugoola. *Occurrences.*—Bald Hill; 2½ miles N. of Woodstock; 4 miles S.W.; and 5 miles S.W. of Woodstock; por. 71, parish Kenilworth; 1 mile N. of Burley Jacky.
	Newbridge	*Occurrence.*—Colo Creek.
	Oberon	Tuglow Mines; Bouchier's; HAMPDEN; Bull's Creek. *Occurrences.*—Bull's Creek, 18 miles from Jenolan; Louther.
	O'Connell	Diamond Hill; Sidmouth Valley; Brewongle.
	Orange	*Mines.*—CARANGERA; OPHIR; ICELY; WILLIAMS; GUROPHIAN; MOONTA; NELSON; CADIA; CANOBLAS; GREAT WESTERN; BRITANNIA; EAST BLOCK, etc. *Occurrences.*—Byng; CORNISH SETTLEMENT; Lewis Ponds; Mullion Range.
	Rockley	*Mines.*—Apsley; Essington; WISEMAN'S CREEK; EYRIE SOUTH; SUMMERHILL; PROSPECT; BELMORE; COW FLAT; Larry's Hill. *Occurrences.*—Native Dog Creek; Campbell's River; Gilmandyke; Bunamagoo; Back Creek; Mountain Run; 5 miles S., and 8 miles N.W. of Rockley; Briar Park; Charlton; Stoney Creek; Sugarloaf.
	Mitchell	SUNNY CORNER AND NEVADA SILVER MINES.
	Trunkey	*Mines.*—Bombah; Kempfield; MILBURN CREEK. *Occurrence.*—Abercrombie River.
	Tuena	*Mines.*—PEELWOOD; CORDILLERA. *Occurences.*—Between Binda and Mulgowrie.
Clarence and Richmond.	Casino	*Occurrences.*—Mt. Lindsay; 6 miles E., and 8 miles N.E. from Solferino; 4 miles from Casino.
	Nana Creek	*Occurrence.*—Bucca Creek District.
	Grafton	*Occurrences.*—Camelback Mountain; Yulgilbar; GORDON BROOK; Ewingar, Oaky, and Deep Creeks, Tabulum. *Mine.*—JAKOONBIE.
Cobar	Bobadah	*Mines.*—Recovery; Sullivan's; Walker's Hill; Yellow Mountain; Mt. Susannah; Overflow.
	Cobar	*Mines.*—GREAT COBAR; Cobar Chesney; Scottish Australian; Burrabungie; MT. BOPPY (late Burra Burra). *Occurrences.*—Gt. Western, Young Australian, and Mt. Pleasant Gold-mines; Bald Hill.
	Gilgunnia	*Occurrences.*—Barcoo and May Day Gold-mines; near The Peaks; Bedooba Station.
	Mt. Hope	*Mines.*—NEW MT. HOPE; GREAT CENTRAL. *Occurrences.*—Coan Peak; Double Peak; Mt. Allen.
	Nymagee	*Mines.*—NYMAGEE; North Nymagee; Wirlong. *Occurrences.*—14 miles S.W. of Nymagee, ; Budgery.
	Nyngan	*Mines.*—GIRILAMBONE. *Occurrences.*—Christensen's Lode; Hartman's Lode.

Mining District.	Mining Division.	Copper Mine or Occurrence.
Hunter and Macleay.	**Copeland**	*Occurrences.*—Brown's Lease; Hooke's Reef; Calf's Creek, Port Macquarie, Nobby's; WILLI WILLI.
Lachlan	Adelong	*Occurrences.*—5 miles from Snowball Mine.
	Alecktown ..	*Occurrences.*—5 and 6 miles W. of Alecktown.
	Boorowa	*Mines.*—Murrumbidgee.
	Boorowa	*Occurrences.*—Binalong District; Bookham, near Yass.
	Canowindra ...	*Mines.*—Fitzroy. *Occurrences.*—Licking Hole Creek; Copper Creek; Marshall's Camp.
	Cargo	*Occurrences.*—Iron Clad and Dalcoath Mines.
	Condobolin ...	Gt. Condobolin, Eureka; Melrose; **Anaconda**; **Big Ben**; Mahgalore. *Occurrences.*—**Morris's** C.P.; Shepherd & Party's Mine.
	Cootamundra	*Occurrences.*—Bethungra; 5 and 8 miles from Cootamundra.
	Cowra	*Occurrences.*—Broula Creek; Neila Creek.
	Cudal	*Mines.*—**Bumbery.**
	Trundle	*Mines.*—CAROLINE, 12 miles W. of Dandaloo; Orange Plains, near Tabratong Station. *Occurrences.*—Burra Burra; Black Range; 42 miles S. of Trumble.
	Forbes	*Mines.*—Eurow; **Vyohan**; PATENS; EUGOWRA.
	Grenfell	*Occurrence.*—Arramagong.
	Gundagai	*Occurrences.*—Back Creek Station, near Kimo; Coolac, and 5 miles N.W.
	Molong	*Mines.*—COPPER HILL; ARMSTRONG; Burt's; Smith's; Peabody; Fidler's Station. *Occurrences.*—Between Molong and Kadumble Range; Bell River; Spring Creek; Larras Lake; Little Copper Hill; Reedy Creek; 6 miles S. of Molong; Delaney's Dyke.
	Jewnee	*Occurrences*—Junee Reefs; Rockdale Mine.
	Parkes	*Mines.*—Gunningbland. *Occurrences.*—Goobang; Goobandry; Goonumbla Hill; Limestone Reserve; Gunningbland; Little Mount Corrumbla; Langford's Lease; Scott's Find.
Mudgee	Cobbora	*Occurrences.*—Pine Ridge Station; S.W. Boundary, Talbragar River.
	Denison Town	*Occurrence.*—Near Coolah.
	Dubbo	*Mines.*—Rose Hill; 4 miles S. of Geurie; Ballimore.
	Gulgong	*Occurrences.*—3 miles from Gulgong; Bungeboema, Boooble.
	Mudgee.........	*Occurrences.*—Lue; Wilbertree; Atkinson's Paddock.
	Cobbora	*Occurrences.*—Leadville, and 7 miles N. of Leadville.
	Wellington ...	*Mines.*—Gt. Wheal Burril; Mt. Bodangora; APSLEY; Kaiser; Fitte's; LINDBERGER'S; BELARA; YARRAGOL; 4 miles from Dripstone. *Occurrences.*—Burril Ranges; Wellington Common; Galwadgery Creek; Newrea; 3-mile Flat; Weandre Creek; Wellbank, near the Springs Railway Station.
New England...	Deepwater ...	*Occurrences.*—Deepwater and neighbourhood; Castle Hill and Castlerag Mines.
	Drake	*Mines.*—**Mt. Carrington Mines; Gt. American Barber; Stanton and Party's; Creed and Party's; Handcock and Party's; Mickle and Party's; Kay and Party's; Adeline.** *Occurrences.*—Mt. Carrington; Sawpit Gully; Red Rock; Great Northern Gold-mines.
	Emmaville ...	*Mines.*—Willow's. *Occurrences.*—Vegetable Creek; Grampians; Bald Nob; Little Plant; Pye's Creek; Glen Creek; Ottery Mine; Paradise; Tent Hill; Bolivia.

Mining District.	Mining Division.	Copper Mine or Occurrence.
New England...	Wilson's Downfall.	*Occurrences.*—**Cullen Creek** ; near Rivertree ; Boonoo Boonoo.
Peel and Uralla	Armidale	*Occurrences.*—10 miles E. of Guyra ; Booroolong.
	Barraba	*Mines.*—**Cornish** ; BUNDARRA. *Occurrences.*—Ironbark Creek ; Gulf Creek ; Emu Creek.
	Bingara........	*Mines.*—Bingara Syndicate ; **Bobby Whitlow** ; PRINCE OF WALES ; Mitchell's ; Corney's ; Harrison's. *Occurrences.*—Bonshaw ; 18 miles from Cornish Mine ; Spring Gully ; Copper Gully ; Upper Bingara.
	Inverell.........	*Occurrences.*—Newstead Tin Mine.
	Glen Innes ..	*Occurrence.*—18 miles from Glen Innes on Grafton Road.
	Hillgrove	*Mines.*—**Sunnyside.** *Occurrence.*—Chandler River.
	Walcha.........	*Occurrences.*—Walcha District ; Blue Mountain Creek.
	Nundle	*Mines.*—**Fisher's** ; Dungowan ; Mount Pleasant ; Bowling Alley Point.
	Tamworth ...	*Occurrence.*—Wood's Reef Gold-mine ; 2 miles south of Wood's Reef.
	Tingha	*Occurrences.*—Hoy's Reef ; Sandy Creek ; near Boggy Camp ; **Borah Creek (Conrad Mine).**
	Walcha	*Mines.*—Coopera Curripa. *Occurrences.*—Near Nowendoc ; Walcha Creek ; Blue Mt. Creek ; Jones' Reef ; 19 miles N.E. of Walcha.
Southern and Tumut and Adelong.	Bombala and Delegate.	*Mine.*—BELMORE ; Quidong.
Southern	Bombala	*Occurrences.*—Parish of Bombala ; Gallagher's Plains.
	Braidwood ...	*Mines.*—**Mulloon Mines.** *Occurrences.*—Boro ; Thames Gully ; Enderick River ; Green Creek ; Major's Creek ; **Mulloon Creek** ; Rigby's Reef.
	Boorowa	*Mines.*—Red Hill ; MAYFIELD ; RYE PARK. *Occurrences.*—Lang's Creek ; Arkstone Forest.
	Captain's Flat	*Mines.*—**LAKE GEORGE MINES** ; Singleton's ; Grogan's.
	Frogmore	*Mines.*—FROGMOOR. *Occurences.*—Lang's Creek ; Arkstone Forest.
	Goulburn	*Mines.*—MUMMELL ; APPLETON ; CURROWONG. *Occurrences.*—Marulan District ; Jacqua Creek ; Bungonia District ; Doctor's Lode ; Cryer's Arm ; Spring Creek ; Budjong, 22 miles from Goulburn ; Shelly's Flat, 4 miles from Marulan ; Crookwell River ; Lake George.
	Ulladulla	*Occurrences.*—Buddawang Mountain ; Conjola ; Little Forest.
	Nelligen	*Occurrence.*—Currawan Creek.
	Nerriga.........	*Occurrence.*—Jerickanora Creek.
	Picton	*Occurrence.*—Burrogorang District ; The Peaks.
	Yalwal	*Occurrences.*—Bundundah Creek ; Dangera Creek ; 4 miles above Yalwal ; TOUGA Mine ; 10 miles from Nerriga.
	Yass	*Mines.*—GOOD HOPE ; WOOLGARLO ; WALLAH. *Occurrences.*—Woolgarlo ; Bowning ; Gooda Creek.
Tambaroora & Turon.	Rylstone	*Mine.*—Cheshire.
	Sofala	*Mines.*—Queen of the Stream ; GOODRICH. *Occurrences.*—4½ miles from Capertee ; Crudine ; Head of Jews or Wallaby Creek ; 5 miles S.W. of Sofala.
	Ironbarks......	*Occurrences.*—Kadumble Mountains ; Ponto ; Burrandong ; near Stuart Town.

Mining District.	Mining Division.	Copper Mine or Occurrence.
Tumut and Adelong.	Adelong	*Mines.*—SNOWBALL.
		Occurrences.—5 and 10 miles S. of Gundagai; Mingary Mountain.
	Cooma	*Mines.*—GYGEDERICK; JINDABYNE; DARTMOOR; Cooma; Sturgeon's; Reynold's; Ingleman's; Dyball's; Jardine's; Fergusson's; COOTRALANTRA; NITHOLME.
		Occurrences.—Middle Flat; ROSEBROOK; Arable Station; Paddy Linda; Bredbo; Wambrook; Blake's Mine; Bushy Hill.
	Delegate	Currowong Mine; Black Jack Range; near Mt. Trooper; Snowy River.
	Kiandra	*Mines.*—Lobb's Hole; Talbingo; Yarrangobilly.
	Queanbeyan...	*Mines.*—Wright's; M'Grath and Party's; Martin and McDonald's; CONGWARRA; Coyle's.
		Occurrences.—Rose Valley; Congwarra; Uriara; Paddy and Cotter Rivers; Queanbeyan Common.
	Bungendore ...	*Mine.*—Walsh's, Bywong.
	Tumberumba	*Occurrences.*—Yowara; Coppabella.
	Tumut	Wyangle; Brungle; Adjungbilly; Kangaroo Mountain; M'Alpine Mine; Kiley's property.

Geological and Petrographical Distribution of the Principal Copper Lodes in New South Wales.

Mines.	Formation.	
	Geological.	Petrological.
Anaconda, near Melrose	Silurian ? ...	Conglomerate and slate.
Apsley, near Cow Flat	Silurian ...	Hornblende schist.
Balaklava, Barrier Range	....	Schist and gneiss.
Barrier Mines, Barrier Range	....	Schist and gneiss.
Belmore, near Cow Flat	Silurian ? ...	Hornblende schist.
Belmore, near Lewis Ponds and Byng	....	....
Belmore, Quidong	Silurian ...	Limestone and shales.
Belara, Wellington and Mudgee	Silurian ...	Schist.
Big Ben, near Melrose	Silurian ...	Conglomerate and slate.
Britania, near Icely	Silurian ? ...	....
Bumbery, near Manildra	... .	.. ..
Bundarra, New England	....	Altered claystone and slate.
Burraga	....	Sedimentary and igneous.
Captain's Flat (Lake George Mines)	Silurian ...	Slates and breccias.
Carangara, near Byng	....	Clay slates, chlorite, talcose, and serpentinous schists.
Cobar	Silurian ...	Slates and sandstones.
Cobar Chesney	Silurian ...	Slates and sandstones.
Congwarra, Paddy's River	....	Limestone and serpentinous rock.
Cow Flat	Silurian ..	Hornblende schist.
Currowong, near Lake George	....	....

Mines.	Formation.	
	Geological.	Petrological.
Dartmoor, near Cooma	Silurian ...	Slates at junction of falsite.
Essington, near Rockley	Silurian ...	Schist.
Eyrie South, Wiseman's Creek	Silurian ...	Schist.
Fisher's, Peel River	....	Schist and jasperoid rocks.
Frogmore, near Burrowa	....	Slate near junction of granite.
Girilambone	....	Slates, schists, and quartzite.
Guroophian, near Icely	....	... .
Icely, near Lewis Ponds	....	....
Melrose, near Melrose	Silurian ...	Slate and conglomerate.
Milburn Creek, near Mount McDonald	Silurian ...	Slates and sandstones.
Moonta, near Byng	....	....
Mount Pleasant, near Nundle	Silurian ...	Slates and altered jasperoid rocks.
Mummell, near Goulburn	Silurian ...	Slate.
New Burra Burra, Mount Boppy	Silurian ...	Chloritic slate at junction of porphyry.
Nelson, near Byng	Silurian ...	....
New Mount Hope, Mount Hope	Silurian ...	Slates and sandstone.
Nuntherungee	....	Slates and sandstone, and quartzite.
Nymagee	Silurian ...	Slate and sandstone.
Ophir, near Carangara	Silurian ...	....
Peelwood	Silurian ...	Slate and schist.
Quigley's Hill, near Blayney	Silurian ...	Slate.
Snowball, near Adelong	Silurian ...	Slate and diorite ?
Sunnyside, Chandler River	Silurian ? ...	Slate and quartzite, near junction of felsite.
Tonga, near Nerriga	Devonian ?	Slate.
Vychan, near Eurow	... .	....
Wiseman's Creek, near Rockley	Silurian ...	Schist.
Willi Willi, Macleay River	Permo-Carboniferous.	Limestone, slate, and diorite.?
Borah Creek, near Boggy Camp	....	Granite.
Cootralantra, near Cooma	....	Granite.
Goodrich, near Yeoval	....	Granite.
Gygederick, Snowy River	....	Granite.
Wallah Wallah, near Burrowa	....	Granite, near slate.
Bobadah	....	Porphyry.
Copper Hill, near Molong	....	Porphyry, near sedimentary.
Great Central, near Mount Hope	....	Porphyry.
Mount Carrington, Drake	....	Porphyry.
Yellow Mountain, near Bobadah	....	Porphyry and sedimentary.
Annandale, Blayney	....	Andesite.
Belmore, Woodstock	....	Andesite and sedimentary.
Bodangora, near Wellington	....	Andesite.
Burley Jacky, near Woodstock	....	Andesite and sedimentary.
Cadia, near Orange	....	Andesite.
Canoblas, near Orange	....	Andesite.
Coombing, near Carcoar	....	Andesite.
Sugarloaf, near Blayney	....	Andesite.
Wellington (Wellington Common)	....	Andesite.
Bingara, Bingara District	....	Serpentine and altered rocks.
Brungle, Tumut District	....	Serpentine.
Ewingar Creek, Clarence River District	....	In or near serpentine.
Gordon Brook, Clarence River District	....	In or near serpentine.
Nogregar Creek, Clarence River District	....	In or near serpentine.
Oaky Creek, Clarence River District	....	In or near serpentine.
Wyangle, Tumut District	....	In serpentine.

The cupriferous andesite of the Blayney District has been microscopically examined by Mr. G. W. Card, A.R.S.M., Curator of the Mining Museum, per medium of samples selected by the writer, and the following descriptions are from his memorandum on the subject:—

"*Blayney.—Annandale Copper Mine.*—Comprising Nos. 2902–5. These are augite andesites in different stages of alteration, the alteration taking the form of a development of epidote and, to some extent, chlorite.

"*Blayney.—Wright and Osborn's, Mount Sugarloaf.*—Comprising Nos. 2899–2901. These are andesites showing a development of epidote, and containing hornblende. I am of opinion, however, that the hornblende is very probably of secondary origin, resulting from *paramorphic* changes in augite.† The augite in 2905 is distinctly *aralitic.*

Professor David and Mr. G. A. Stonier pointed out* that the crater cones of the Canoblas, near Orange, are andesites, and inferred therefrom that the cupriferous andesitic rocks of the same character in the neighbourhood were flows, and probably had their source in these old volcanic orifices.

Local Refractory Materials used in the Manufacture of Firebrick.

From a consideration of the composition of local refractory materials utilised at various centres, as revealed by the following analyses, it would appear that almost any siliceous grit or sand with just sufficient clay to bind it will withstand the melting temperature of copper (2,000° F., or 1,093 Cent. according to Dr. Peters) long enough to serve a useful purpose in smelting furnaces far removed from supplies of the ordinary market firebrick. The composition of some of the far western bricks brings them into class with pure silica bricks, as the cementing clay is found to be also largely silica. In some cases the materials are crushed; in others, they are used in the extemporised pug-mill just as obtained; fragments and pebbles of quartz—as at Girilambone—are frequently as large or even larger, than marbles; none the less, the resulting bricks answer all their requirements sufficiently well to enable the imported article being dispensed with, and thus ensuring a considerable saving in carriage. Cost of transit was a most serious item in the early days of the Cobar Copper-field. The first firebricks transported from Sydney to Cobar are reported to have cost £50 per thousand. Later they were manufactured locally from a clay brought from Tindarey—about thirty-six miles northerly from the mine—by the copper-teams returning from Bourke for loading. Subsequently a reward was offered for the discovery of suitable clay at a more convenient distance, and a site was selected about six miles north-westerly from the mine. This clay, of which the following analysis was made in the Departmental Laboratory, was used in equal parts with crushed quartz and fine-grained sandstone obtained near by. From this mixture the local firebrick was manufactured, until the use of refractory material ceased on the advent of water-jacketted furnaces in 1893–4.

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* Annual Report Department of Mines, 1890, p. 239.
† Records Geol. Survey N. S. Wales, IV, Pt. 4, p. 150.

Analysis of Clay from six miles north-westerly from Cobar, used with crushed quartz and sandstone in the manufacture of firebricks for the reverberatory copper furnaces.

Chemical Composition.

No. $\frac{3061}{98}$.—	Moisture at 100° C	1·75
	Combined water	4·54
	Silica (SiO_2)	65·82
	Alumina (Al_2O_3)	20·74
	Ferric oxide (Fe_2O_3)	1·45
	Maganous oxide (MnO)	trace
	Lime (CaO)	·10
	Magnesia (MgO)	·97
	Potash (K_2O)	4·58
	Soda (Na_2O)	·07
	Phosphoric acid P_2O_5)	minute trace
	Sulphur trioxide (SO_3)	·19
		100·21

Both Waratah and Lithgow firebricks were used at the commencement of smelting at Girilambone, but a locally-manufactured article has superseded both. The life of the latter has been satisfactory, lasting about eight weeks in the hottest parts of the furnaces. It consists essentially of about 95 per cent. of silica in the form of coarse quartz gravel and sand, with just enough clay to bind it tolerably well. It undergoes no preparation prior to puddling. The following analysis was made of the clay separated by washing from the quartz gravel and sand:—

Chemical Composition.

No. $\frac{2887}{98}$.—	Water	15·02
	Silica (SiO_2)	50·50
	Alumina (Al_2O_3)	22·15
	Ferric oxide (Fe_2O_3)	6·21
	Ferrous oxide (FeO)	2·46
	Manganous oxide (MnO)	absent
	Lime (CaO)	0·30
	Magnesia (MgO)	1·04
	Potash (K_2O)	2·32
	Soda (Na_2O)	·27
	Phosphoric acid (P_2O_5)	·17
		100·44

The New Mount Hope and Great Central firebricks are made wholly from a sandy clay obtained at a depth of about 60 feet, at a distance of seven miles from Mount Hope, first discovered in sinking a well for water. Most durable firebrick is made from it direct after crushing. They are now burned in one of the old reverberatories. The clay is of Tertiary age, and contains sub-angular quartz pebbles. The materal was panned off, and the percentage of quartz determined, viz., quartz and sand, 68·8 per cent. Following is an analysis of the fine-clay settlings from the pannings:—

Chemical Composition.

No. $\frac{2682}{98}$.—Moisture at 100° C.	·61
Combined water	7·33
Silica (SiO_2)	63·00
Alumina (Al_2O_3)	25·75
Ferric oxide (Fe_2O_3)	1·24
Manganous oxide (MnO)	trace
Lime (CaO)	·40
Magnesia (MgO)	trace
Potash (K_2O)	1·69
Soda (Na_2O)	·14
Phosphoric acid (P_2O_5)	trace
Sulphur trioxide (SO_3)	·10
	100·26

The Waratah (near Newcastle) firebricks are so well and favourably known in local smelting works that this section would be incomplete without an analysis of the shale principally used in their manufacture. It belongs to the Permo-Carboniferous Coal Measures of the Newcastle Coal-field:—

Chemical Composition.

No. $\frac{3067}{98}$.—Moisture at 100° C	2·88
Combined water	·86
Silica (SiO_2)	65·40
Alumina (Al_2O_3)	19·01
Ferric oxide (Fe_2O_3)	5·36
Ferrous oxide (FeO)	absent
Manganous oxide (MnO)	minute trace
Lime (CaO)	·05
Magnesia (MgO)	·07
Soda (Na_2O)	·29
Potash (K_2O)	·35
Phosphoric acid (P_2O_5)	absent
Sulphur trioxide (SO_3)	·13
	100·40

Fireclay used at the Burraga Smelting Works—obtained about two miles distant.

Chemical Composition.

No. $\frac{4304}{98}$.—Moisture at 100° C.	·25
Combined water	1·57
Silica (SiO_2)	90·52
Alumina (Al_2O_3)	4·71
Ferric oxide (Fe_2O_3)	1·91
Manganous oxide (MnO)	trace
Lime (CaO)	·34
Magnesia (MgO)	·30
Potash (K_2O)	·63
Soda (Na_2O)	·10
Phosphoric acid (P_2O_5)	·02
Sulphur trioxide (SO_3)	trace
Organic matter	,,
	100·05

Locality—Eskbank—Mixed clays used in the manufacture of fire-brick at Farrant's Brick Works, Eskbank. Used at the Great Cobar Syndicate's Copper Refinery, Lithgow.

Chemical Composition.

No. $\frac{602}{99}$.—	Moisture at 100° C	·40
	Combined water	3·12
	Silica (SiO_2)	88·80
	Aluminia Al_2O_3)	5·74
	Ferric oxide (Fe_2O_3)	1·12
	Manganous oxide (MnO)	trace
	Lime (CaO)	·20
	Magnesia (MgO)	trace
	Potash (K_2O)	·50
	Soda (Na_2O)	·14
	Phosphoric acid (P_2O_5)	·09
	Sulphur trioxide (SO_3)	trace
		100·11

As a guide to the localities of refractory materials suitable for the manufacture of firebrick, the following analyses are extracted from the Annual Reports of the Department of Mines, with the remarks of the Departmental Analyst, Mr. J. C. H. Mingaye, F.C.S. :—

Locality—County Cumberland. (?)—(Ann. Rept., $\frac{1882}{\text{p. }46}$.)

Moisture at 100° C.	1·45
Combined moisture	3·44
Silica	80·79
Alumina	13·20
Oxide of iron	·86
Oxide of manganese	nil
Lime	·15
Magnesia	traces
Alkalies, loss, &c.	·11
	100·00

"Remarks.—This is an excellent description of fire-clay, and can be classed as equal, if not superior, in quality to the English imported article. It should prove useful for the manufacture of firebricks, tiles, &c., and perhaps might be utilised for the manufacture of crucibles. The percentage of silica is higher than that usually present in the English fireclays."

Locality—Narrabeen, near Manly.—(Ann. Rept., $\frac{1891}{\text{p. }60}$.)

Silica	89·45
Alumina	10·40
Oxide of iron	trace
Lime	,,
Magnesia	,,
Potash	·32
Soda	·36
Titanic acid	trace
	100·53

"Remarks.—The clay was finely ground, damped with water, and fashioned into two small bricks with sharp edges, which were, after drying, submitted to a severe heat in an assay furnace. The bricks were solid and burnt white, the sharp edges being retained. I am of opinion that this clay is suitable for the manufacture of a good description of firebrick."

Shale with Plant Impressions from Parramatta [Wianamatta Series.—J.E.C.]—(Ann. Rept., $\frac{1891}{\text{p. 61}}$.)

Moisture at 100° C.	1·05
Combined water	2·35
Ferric oxide (Fe_2O_3)	·79
Ferrous oxide (FeO)	nil
Manganous oxide (MnO)	trace
Alumina (Al_2O_3)	8·81
Silica (SiO_2)	85·35
Lime (CaO)	nil
Magnesia (MgO)	·43
Potash (K_2O)	1·48
Soda (Na_2O)	trace
Phosphoric acid (P_2O_5)	„
Sulphuric acid (SO_3)	nil
Titanic acid (TiO_2)	trace
	100·26

"Remarks.—Experiments were conducted as to the fire-resisting properties of this clay. Bricks were made of it and burnt, also with the addition of 25 to 35 per cent. of silica. From the results obtained, and on comparing the analysis made with those of British fireclays, I am of opinion that this clay is suitable for the manufacture of firebrick."

Locality—Towrang. White Felspathic Sandstone Rock.—(Ann. Rept., $\frac{1891}{\text{p. 61}}$.)

Moisture at 100° C. } Combined water }	4·78
Silica	80·88
Alumina	13·86
Oxide of iron	·51
Oxide of manganese	nil
Lime	·15
Magnesia	trace
Titanic acid	„
Potash	„
Soda	„
	100·18

"Remarks.—This is an excellent description of fireclay?, and from the large percentage of silica present, should prove very refractory."

Locality—Cremorne Bore, Sydney Harbour. Micaceous Shaly Sandstone from between 1,200 feet and 1,300 feet in No. 2 Cremorne Diamond Drill Bore in search of Coal.—(Ann. Rept., $\frac{1892}{\text{p. 56}}$.)

Moisture at 100° C.	·22
Combined water	1·02
Silica (SiO_2)	89·64
Alumina (Al_2O_3)	6·53
Ferric oxide (Fe_2O_3)	1·94
Manganous oxide (MnO)	trace
Lime (CaO)	„
Magnesia (MgO)	·03
Potash (K_2O)	·83
Soda (Na_2O)	·07
Phosphoric acid (P_2O_5)	trace
Sulphuric acid (SO_3)	nil
Carbon dioxide (CO_2)	„
	100·30

"Remarks.—Two small bricks were made of this material, and submitted to the highest heat obtainable in the coke assay furnace, with the result that no fusion had taken place, the sharp edges being retained."

Locality—Forster (?), Cape Hawke, North Coast.—(Ann. Rept., 1892, p. 67.)

Moisture at 100° C.	2·88
Combined water	5·95
Silica (SiO_2)	70·57
Alumina (Al_2O_3)	16·27
Ferric oxide (Fe_2O_3)	1·07
Ferrous oxide (FeO)	nil
Manganous oxide (MnO)	"
Lime (CaO)	·13
Magnesia (MgO)	·38
Potash (K_2O)	2·20
Soda (Na_2O)	·27
Phosphoric anhydride (P_2O_5)	nil
Sulphuric anhydride (SO_3)	·41
Titanic acid (TiO_2)	nil
Organic matter	"
	100·13

"Remarks.—Bricks made from this clay and submitted to a high heat in the coke assay furnace showed no fusion, the sharp edges being retained. The bricks appear to be of excellent quality."

Locality—Aberdare Coal Mine, Swan Bay, Richmond River. Light grey-coloured clay, 6 feet thick.—(Ann. Rept., 1892, p. 59.)

Moisture at 100° C.	2·37
Combined water	6·07
Silica	65·17
Alumina	21·89
Ferric oxide	·19
Manganous oxide	nil
Lime	·50
Magnesia	1·03
Potash	2·02
Soda	1·16
Phosphoric acid	trace
Sulphuric acid	nil
Titanic acid	"
Organic matter	"
	100·40

"Remarks.—Several small bricks, with and without the addition of silica, were made of this clay and carefully dried, then submitted to a high heat in the coke assay furnace, with the result that no fusion took place, the sharp edges being retained. The bricks had the appearance of being excellent firebrick." [Several other analyses of this shale were made with approximate results.—J.E.C.]

Locality—Heathcote, Southern Line.—(Ann. Rept., $\frac{1892}{p.52}$.)

	(749)	(750)	(751)
Moisture at 100° C.	......	1·64	1·76
Combined water	4·57	3·33	5·56
Silica	74·48	78·31	72·41
Alumina	18·83	15·29	16·70
Ferric oxide	·39	·74	·28
Manganous oxide	trace.	trace.	1·00 (ferrous oxide
Lime	"	"	·45
Magnesia	·72	"	·36
Potash	1·63	......	1·45
Soda	nil.	1·29	
Phosphoric anhydride	trace.	trace.	trace.
Sulphuric acid	"	nil.	"
Titanic acid	"	"	"
	100·59	100·00	100·00

Locality—Port Stephens. Gritty White Clay.—(Ann. Rept., $\frac{1893}{p.53}$.)

Moisture at 100° C.	1·84
Combined water	4·36
Silica	74·57
Alumina	16·47
Lime	·17
Magnesia	trace
Ferric oxide	1·18
Manganous oxide	trace
Potash	1·03
Soda	nil
Phosphoric acid	nil
Sulphuric acid	trace
Titanic acid	nil
	99·62

Locality—Pyrmont, Sydney. Sandstone used as firestone. Hawkesbury (Triassic) Series.—(Ann. Rept., $\frac{1894}{p.65}$)

Moisture at 190° C.	·45
Combined water	1·40
Silica	87·60
Alumina	8·53
Ferric oxide	·03
Ferrous oxide	·10
Manganous oxide	nil
Lime	·60
Magnesia	·29
Potash	·28
Soda	·45
Phosphoric acid	trace
Sulphuric acid	·11
Chloride of sodium	trace
Soluble silica	·40
	100·24

LIMESTONE.

Limestone Flux, Cobar District.—Limestone is now rarely used at the Cobar Copper Mine. When formerly required it was obtained from the Lime-kilns about twenty-six miles distant towards Nymagee. A geological examination has not yet been made of the locality, but from a few specimens of fossils from the limestone it appears to be of Upper Silurian age.

Small concretionary segregated nodules of magnesian limestone occur occasionally in the slates and sandstones in the immediate vicinity of Cobar, but in too limited quantity to be of any value.

The composition of the latter has been determined in the following analysis:—

Chemical Composition.

No. $\frac{2962}{95}$.—Moisture at 100 C	·81	Insoluble in acids. = 27·33 %.	
Combined water	1·10		
Silica (SiO_2)	19·08		
Alumina (Al_2O_3)	6·61		
Magnesia (MgO)	·62		
Potash (K_2O)	1·02		
Soda (Na_2O)	trace		
Calcium carbonate ($CaCO_3$)	39·42	Soluble in acids. = 71·08 %.	
Magnesium carbonate ($MgCO_3$)	30·17		
Ferric oxide (Fe_2O_3)	1·49		
Alumina (Al_2O_3)	trace		
Phosphoric acid (P_2O_5)	minute trace		
Sulphur trioxide (SO_3)	absent		
	99·82		

A considerable outcrop of encrinital limestone occurs about ten miles from Nymagee Copper Mine, on the Bobadah Road. It is held under lease in reserve for smelting operations which are contemplated at the Overflow Gold, Silver, and Copper Mine, Bobadah. It is probably of Upper Silurian age, though no identifiable fossils have yet been obtained. It is of excellent quality, as will be seen by the following partial analysis:—

No. 3460.—Gangue (sand)	1·73	
Calcium carbonate ($CaCO_3$)	97·39	CaO 54·54 %
Alumina and ferric oxide	·41	
Magnesia	·20	
	99·76	

A small quantity of iron pyrites present.

Close to the Anaconda, Big Ben, and Melrose Copper Mines, near Melrose, a thin superficial deposit of pulverulent carbonate of lime occurs, resting on the slates of the locality over a small area. It appears to have resulted from local deposition. Its chemical composition has been determined as follows:—

No. $\frac{2328}{95}$.—Moisture at 100°C	·45
Organic matter	·73
Calcium carbonate ($CaCO_3$)	92·67
Magnesium carbonate ($MgCO_3$)	1·05
Silica (SiO_2)	3·34
Ferric oxide (Fe_2O_3) / Alumina (Al_2O_3)	1·50
Sulphur trioxide (SO_3)	nil
Phosphoric acid (P_2O_5)	trace
	99·74

Limestone used as flux at Captain's Flat (Lake George Mines) obtained about three miles from the mines on the road towards Bungendore—(Mine assay).

Lime carbonate ($CaCO_3$)	99·00 per cent.
Ferrous oxide (FeO)	·06 „
Silica (SiO_2)	·86 „
	99·92

The general average of the flux is from 96 to 98 per cent.

Statistical Return of the Production of Copper in New South Wales.

The following figures are from the Annual Reports of the Under Secretary for Mines. Between the gross amount of copper exported according to this authority and that estimated by the Government Statistician, a serious discrepancy exists, as will be seen by reference to the table. The difference is accounted for by deducting from the gross amount of exports the quantity and value of ores imported into the Colony for smelting purposes, according to the Customs returns, which is the strictly correct method of computation.

Table showing the quantity and value of Copper exported from New South Wales, from 1858 to 1898.

Year.	Ingots.		Ore and Regulus.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	tons cwt.	£	tons cwt.	£	tons cwt.	£
1858	... .	....	58 0	1,400	58 0	1,400
1859	30 0	578	....	....	30 0	578
1860	....	....	43 0	1,535	43 0	1,535
1861	....	....	144 0	3,390	144 0	3,390
1862	....	....	213 0	5,742	213 0	5,742
1863	23 0	1,680	114 0	420	137 0	2,100
1864	54 0	5,230	....	....	54 0	5,230
1865	247 0	15,820	22 0	545	269 0	16,365
1866	255 0	18,905	23 0	1,885	278 0	20,790
1867	393 0	30,189	0 2	5	393 0	30,194
1868	644 0	23,297	172 10	4,000	816 0	27,297
1869	1,980 0	74,605	104 0	2,070	2,084 0	76,675
1870	994 0	65,671	6 0	60	1,000 0	65,731
1871	1,350 0	87,579	94 0	1,297	1,444 0	88,876
1872	1,035 0	92,736	417 0	13,152	1,452 0	105,888
1873	2,795 0	237,412	51 0	1,690	2,846 0	239,102
1874	3,638 0	311,519	522 0	13,621	4,160 0	325,140
1875	3,520 0	297,334	157 0	4,356	3,677 0	301,690
1876	3,106 0	243,142	169 0	6,836	3,275 0	249,978
1877	4,153 0	307,181	360 0	17,045	4,513 0	324,226
1878	4,983 0	337,409	236 0	7,749	5,219 0	345,158
1879	4,106 15	256,437	36 7	915	4,143 2	257,352
1880	5,262 10	359,260	131 18½	4,799	5,394 8½	364,059
1881	5,361 0	350,087	132 16	4,975	5,493 16	355,062
1882	4,865 3	321,887	93 1	2,840	4,958 4	324,727
1883	8,872 17	574,497	84 10	2,704	8,957 7	577,201
1884	7,286 6	415,601	18 18	578	7,305 4	416,179

Year.	Ingots.		Ore and Regulus.		Totals.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1885	5,745 5	264,905	0 15	15	5,746 0	264,920
1886	3,968 18	166,429	57 18	1,236	4,026 8	167,665
1887	4,463 19	195,752	299 8	3,350	4,763 7	199,102
1888	3,786 1	272,110	113 6	2,924	3,899 7	275,034
1889	3,983 16	203,319	198 4	3,322	4,182 0	206,641
1890	3,165 9	163,537	580 9	9,774	3,755 18	173,311
1891	3,860 3	191,878	665 8	13,215	4,525 11	205,093
1892	3,535 0	160,473	1,299 4	27,233	4,834 4	187,706
1893	1,051 0	44,235	1,016 0	14,191	2,067 0	58,426
1894	1,556 11	61,034	580 6	12,447	2,136 17	73,481
1895	2,793 3	119,300	1,058 0	21,585	3,851 3	140,885
1896	4,453 0	200,236	14 17	75	4,467 17	200,311
1897	6,756 3	299,829	166 5	851	6,922 8	300,680
1898 (Customs Returns).	5,653 19	280,048	178 9	23,839	5,832 8	280,887
	119,726 18	7,051,641	9,631 11½	214,666	129,367 9½	7,265,807*

* Includes copper refined from New South Wales and imported ores.

According to the Annual Reports of the Department of Mines and Agriculture for 1897 and 1898, the number of miners and smelters engaged in copper mining and smelting in New South Wales was 1,713 in 1897, and 1,976 in 1898. This, of course, does not include the timber, firewood, and flux getters.

Net Export of Copper, Matte and Ore, from N.S.W. from 1858 to 1898. (New South Wales Statistical Register, T. A. Coghlan, 1895, p. 912).

1859 to 1877	£408,071	1889	£122,444
1877	127,396	1890	84,107
1878	209,030	1891	119,195
1879	210,623	1892	114,559
1880	268,700	1893	73,287
1881	257,884	1894	63,617
1882	182,473	1895	136,969
1883	472,982	1896	*197,814
1884	362,287	1897	†283,174
1885	170,993	1898	‡280,887
1886	122,990		
1887	115,444	Total to end of 1898	£4,693,185
1888	247,304		

Statistical Return of Copper produced in Australasia to end of 1897 (Coghlan, Seven Colonies of Australasia, 1897–8, p. 524).

South Australia	£21,280,889
New South Wales	4,351,343
Queensland	2,020,761
Tasmania	491,876
Victoria	206,395
Western Australia	167,849
New Zealand	17,868
Total	£28,536,981

* Wealth and Progress of N.S.W., 1896–7, p. 216. † Seven Colonies of Australasia, Coghlan, p. 523. ‡ Custom Returns.

THE WORLD'S PRODUCTION OF COPPER—

Principal Copper Supplies (in English tons of Fine

	1897.	1896.	1895.	1894.	1893.	1892.	1891.
Algeria	....	....	35	....	....	....	120
Argentina	200	160	150	220	160	200	210
Australasia	17,000	11,000	10,000	9,000	7,500	6,500	7,500
Austria	1,210	1,075	1,110	1,810	1,215	1,100	965
Bolivia—Corocoro	2,200	2,000	2,250	2,300	2,500	2,800	2,150
Canada	5,905	4,000	*4,000	*5,000	*5,000	*3,500	3,500
Chili	21,900	23,500	22,075	21,340	21,350	22,565	19,875
Cape of Good Hope—							
Cape Co.	5,290	5,470	5,350	5,000	5,300	5,500	5,000
Namaqua	2,150	1,980	1,730	1,500	890	450	900
England	*550	555	580	445	425	495	720
Germany—							
Mansfeld	17,960	18,265	14,860	14,900	14,150	15,360	14,250
Other German	2,185	1,800	1,695	2,210	2,000	1,935	1,900
Hungary (including Bosnia and Servia	445	210	200	310	210	285	235
Italy	3,400	3,400	*2,500	2,690	2,500	2,500	2,200
Japan	23,000	21,000	18,430	20,050	18,000	18,000	17,000
Mexico—							
Boleo	10,170	9,940	10,450	10,370	7,980	6,415	4,175
Other Mexican	*1,200	1,210	1,170	1.400	590	900	1,025
Newfoundland—							
Betts Cove	....	....	....	100	240	450	540
Tilt Cove	1,800	1,800	1,890	1,800	1,800	1,940	1,500
Norway—							
Vigsnaes	....	....	960	985	1,670	785	615
Other Norwegian	3,450	2,500	1,725	905	790	625	632
Peru	1,000	740	450	440	460	290	230
Russia	*6,000	5,100	5,280	5,000	5,000	4,900	4,800
Sweden	545	500	515	350	535	735	655
Spain and Portugal. Rio Tinto	33,900	33,000	33,500	33,000	31,100	31,500	32,000
Tharsis	*12,000	12,000	12,000	11,000	11,000	*11,500	*10,500
Mason and Barry	*4,300 } 54,060	*3,900 } 53,325	*4,100 } 54,950	*4,200 } 54,175	*4,400 } 53,995	*4,400 } 56,462	*4,150 } 53,915
Sevilla	810	1,025	1,050	1,170	1,270	1,070	875
Other Mines	3,050	3,400	4,300	4,805	6,225	7,992	6,390
United States of America. Calumet and H.	*40,400	40,383	34,454	27,675	27,675	32,250	29,000
Other Lake	24,301	24,286	23,582	23,450	22,835	22,210	22,505
Anaconda	58,697 } 216,108	55,603 } 208,893	41,988 } 172,300	42,410 } 159,695	33,600 } 147,210	45,000 } 152,620	20,750 } 128,170
Other Mont.	44,831	37,673	40,606	37,320	35,700	27,000	29,736
Arizona	35,979	31,548	21,429	19,690	12,600	17,160	17,723
Other States	11,900	14,400	10.246	9,150	7,890	9,000	8,415
Venezuela—Aroa	....	....	....	2,500	2,850	3,100	6,500
	396,728	373,363	334,565	324,505	303,530	310,472	279,391

Those marked with an

Average of prices of G.M.Bs. on the 1st of each month.	£49 0s. 10d.	£47 4s. 8d.	£42 17s. 6d.	£40 2s. 6d.	£43 6s. 9d.	£45 9s. 6d.	£51 3s.

1881 to end of 1897.

Copper), compiled by Henry R. Merton & Co., London.

1890.	1889.	1888.	1887.	1886.	1885.	1884.	1883.	1882.	1881.
120	160	50	150	110	250	260	*600	*600	*600
150	190	150	170	180	233	159	293	800	307
7,500	8,300	7,450	7,700	9,700	11,400	14,100	*12,000	*11,000	10,000
1,210	1,225	1,019	883	733	535	670	*500	*455	455
1,900	*1,200	1,450	*1,300	1,100	*1,500	*1,500	1,680	3,259	2,655
3,050	2,500	*2,250	1,450	1,560	1,200	1,000	1,055	500	500
26,120	24,250	31,240	29,150	35,025	28,560	41,648	41,099	42,909	37,960
5,000	5,600	5,800	5,950	5,390	5,080	5,000	5,000	5,800	5,087
1,450	*2,100	1,700	1,300	625	450	....	....	....	....
935	905	1,456	389	1,471	2,773	3,350	2,620	3,464	3,875
15,800	15,506	18,880	13,025	12,595	12,450	12,582	12,643	11,516	10,909
1,825	*1,850	*1,850	*1,850	*1,870	*2,800	*2,200	*2,000	*1,800	1,743
300	800	858	581	866	*600	600	790	660	815
2,200	*3,500	3,500	2,500	2,100	*2,000	*2,000	*1,600	*1,400	*1,430
15,000	15,000	11,600	*11,000	*12,080	*10,000	*10,000	*7,600	*4,800	*3,900
8,450	3,280	2,566	1,950	....	....	....	....	....	....
875	500	200	100	250	375	291	489	401	333
735	1,115	1,300	1,180	1,125	778	668	1,053	1,500	1,718
1,000	1,500	750	125	....	....	....	....	....	....
925	1,007	1,020	1,150	1,920	2,180	2,390	2,340	2,300	2,350
465	485	300	275	330	380	392	322	*290	200
150	275	250	50	75	229	362	395	440	615
4,800	4,070	4,700	5,000	4,875	5,100	4,700	4,400	4,000	3,700
830	830	1,036	905	520	775	662	732	798	905
30,000	29,500	28,500	28,500	24,700	23,484	21,564	20,472	17,389	16,666
*10,300	*11,000	*11,000	*11,000	*11,000	*11,500	*10,800	*9,800	*9,000	*10,203
*5,600 } 51,700	*5,250 } 54,270	*7,000 } 56,450	*7,000 } 53,706	*7,000 } 49,653	*7,600 } 47,873	*7,500 } 46,415	*8,000 } 44,607	*8,000 } 39,560	*8,170 } 39,258
810	1,350	1,700	2,300	2,135	1,800	2,000	2,026	1,885	1,340
4,990	7,170	8,250	4,906	4,818	4,089	4,551	4,309	3,296	2,879
26,250	21,700	22,450	20,550	22,550	21,075	18,050	14,750	14,300	13,995
18,200	17,069	16,200	12,780	13,040	11,135	12,875	11,900	11,140	10,355
23,600	27,500	23,225	25,450	14,850	16,070	10,265			
20,960 } 110,325	19,018 } 105,774	15,478 } 101,710	9,775 } 79,109	10,870 } 69,805	14,200 } 74,050	8,990 } 64,700	} 11,010 } 51,570	} 4,045 } 40,470	} 30,882
15,945	14,419	14,062	8,033	6,985	10,135	11,935	10,660	5,080	6,532
6,370	6,068	5,295	2,519	1,510	1,485	2,585	3,250	2,955	
5,649	5,563	4,000	2,900	3,708	4,111	4,600	4,018	3,700	2,823
269,455	261,205	258,026	223,798	217,086	225,592	220,249	199,406	181,622	163,369

asterisk are estimated.

£54 1s.	£49 10s. 6d.	£76.	£42 3s.	£40 6s.	£44 1s. 6d.	£54 15s. 6d.	£63 8s. 9d.	£67 0s. 6d.	£61 1s. 3d.

Government Metallurgical Works.

Department of Mines, and Agriculture,
Sydney, 22nd September. 1896.

Government Metallurgical Works, Clyde, New South Wales.

The attention of persons interested in mining in New South Wales is drawn to the following Regulations relating to these Works :—

Bulk samples of gold ores up to 10 tons in weight from any one mine or distinctive section of a mine will be received with a view of determining the value of the ore and the best and most economical method to be adopted for its treatment. The local conditions prevailing at the mine will be a factor in any determination arrived at.

Only in cases of doubt or special difficulty, or by express sanction of the Secretary for Mines and Agriculture, will more than 10 tons be taken from the same source.

Each parcel will be weighed, passed through a rock breaker, if necessary, accurately sampled by special machinery, and the actual value of the ore determined by assay before the extraction of the gold is commenced.

Samples will be taken at various stages during the treatment, so that the whole process can be studied, and upon the completion of the work a report will be made showing the value of the ore, the treatment to which it has been subjected, the yield of gold and the loss, and suggestions offered as to the further treatment of similar ore, in order that the loss may be reduced to a minimum.

The Government Metallurgist must be notified of the intention to forward any parcel of ore before despatch thereof to enable that officer to make necessary arrangements.

Applicants will be informed by the Government Metallurgist when he will be ready to receive their ore.

Application should be made on the prescribed Form A.

The fee, in accordance with the scale of charges, must be remitted to the "Registrar," Department of Mines, on the accompanying Form B. The necessary forms may be obtained free of charge from all Mining Registrars.

The ore must be delivered at the works with fees and carriage prepaid, otherwise it will not be treated.

The charge for crushing, sampling, assaying, amalgamating, and concentrating gold ores will be as follows :—

		s.	d.	
For 1 ton the charge will be		45	0	
2 tons	do	30	0	per ton.
3 do	do	25	0	do
4 do	do	22	6	do
5 do	do	21	0	do
6 do	do	20	0	do
7 do	do	19	6	do
8 do	do	19	0	do
9 do	do	18	6	do
10 do	do	18	0	do

Less than one ton will be charged as one ton.

For weighing, coarse crushing, and sampling only, other ores or materials, without assaying, the charges will be one-fifth of the above rates.

For weighing and sampling materials already crushed—*i.e.*, tailings, concentrates, &c.—the charges will be one-tenth of the rates quoted.

The owner of the parcel of ore, or his representative, may attend to the works to see the parcel sampled, and watch, with the permission of the Superintendent, the further treatment of the ore, but no interference with the work in hand will be permitted.

Products held to be of value by the owner must be removed promptly after the report on the treatment has been supplied. It will not be possible to keep all parcels distinct for an indefinite period, and the Department accepts no risks or responsibility in connection with any of the samples or products.

In cases where it can be clearly shown that the owner is not in a position to pay for the cost of treatment, the work may, on the recommendation of the Prospecting Board, be undertaken at the expense of the Department.

All samples will, as far as practicable, be treated in the order in which they are received.

Regulations relating to the Assaying of Small Samples of Ores and the Examination of Minerals.

With the object of encouraging prospecting, auriferous and other ores will be assayed and minerals will be examined and named free of cost, on the following conditions:—

The samples should be addressed to the Government Geologist, Department of Mines, Sydney.

The ores or minerals must be from deposits occuring within the Colony of New South Wales.

Each sample must bear a distinguishing mark, in order that it may be identified readily.

Samples must be accompanied by a letter, in which must be stated the distinguishing mark placed upon each sample and the locality where the deposit occurs.

The samples of ore for assay should weigh about 1 lb. each, and should be fairly representative samples of the lode or deposit, and not picked specimens.

Samples of ore in which free gold is visible to the naked eye will not be assayed.

Assays for the purpose of checking the work of private assayers will not be made by the Department.

Assays of tailings or concentrates from batteries or other crushing mills will not be made, unless reasons are furnished which appear to the Secretary for Mines and Agriculture sufficient to justify such being made at the expense of the Department.

The Department reserves to itself the right to refuse to make an assay of any sample sent.

Form A.

Application for Treatment of Ore at Government Metallurgical Works, Clyde.

Address

Date

Sir,

I have the honour to advise you of my intention to forward a parcel of ore, comprising about tons, and will be glad to be informed of the date upon which you will be prepared to receive it.

I am, Sir,
Your obedient servant,

The Government Metallurgist.

Locality of deposit..............................	
Description of lode..............................	
Particulars of treatment of ore from same deposits, giving description of plant employed, &c., details of yield, and difficulty met with.	

Form B.

Address

Date

To the Registrar,
Department of Mines and Agriculture, Sydney.

Sir,

I have the honor to forward herewith for £ ,* being the charge for treating a parcel of ore, weighing tons cwts. qrs. lb., forwarded this day by me to the Government Metallurgical Works, Clyde.

I am, Sir,
Your obedient servant,

P.S.—Kindly send amount by cheque on Sydney bank, bank draft, or money order or or postal notes, country cheques not being accepted at The Treasury.

SYDNEY SMITH.

* Insert here the amount.

Local Customs Smelting Companies and their Tariffs.

English and Australian Copper Company, Limited.—Established 1851.

Chief office in the Colonies: Port Adelaide, South Australia; Branch works: Waratah, near Newcastle, New South Wales; London office: 142 and 143 Palmerston Buildings.

This company purchases copper ore in any quantities, paying market price for the copper contained therein as shown by assay.

The charge for smelting varies according to the nature of the ore and other circumstances, but does not exceed 40s. per ton of 21 cwt. in any case.

Ores are purchased delivered at the company's works at Port Adelaide, S.A., or Waratah, N.S.W., but sellers can arrange for railway carriage or freight to be paid by the company and deducted in account sales.

Three samples will in all cases be taken—one to be retained by the vendor, one by the company, and the third to be sealed and kept as a reference sample.

The vendor or his agent may be present during weighing and sampling.

When the vendor's assay differs from that of the company, the difference will be divided if it does not amount to more than one per cent.; if greater, the reference sample will be submitted to an independent assayer (to be selected by agreement), and payment made on the middle assay of the three.

The Company pays for the whole of the copper contained in the ore, as shown by fire assay. When vendor's assays are made by wet method, the following deductions will be made from the result so obtained:—

Ores assaying 12 per cent. or under, deduct one per cent.
Over 12 and under 20 per cent., deduct one and a quarter per cent.
Over 20 and under 35 per cent., deduct one and a half per cent.

Other conditions as to sampling, weighing, &c., &c., as usual in the copper smelting business.

Payment by cheque or cash immediately assays are agreed. If desired by sellers, advances up to 90 per cent. of the estimated value of the ore will be made upon the day it is delivered at the company's works.

The company also purchases auriferous or argentiferous copper ores and mattes, paying for the copper upon the terms quoted above, and for the gold and silver at the market price for standard gold and silver in London at date of sampling. A small deduction is made from the gold and silver contents to cover unavoidable loss in treatment, the only additional charge being 3d. for each percentage of copper for separation of gold, and (or) 1s. for each percentage of copper for separation of silver.

For the English and Australian Copper Company, Limited—F. S. Chany, Manager, Port Adelaide, South Australia, or F. Cast, Local Manager, Waratah, New South Wales.

The Smelting Company of Australia (Ltd.)

Head Office, Mutual Life Building, Martin-place, Sydney; Works: Lake Illawarra, near Dapto Railway Station, 57 miles from Sydney, New South Wales.

The company is prepared to purchase gold, silver, lead, and copper ores in any quantities, under the following tariff: On application a printed circular will be sent, giving full details as to the general terms and conditions upon which ore is purchased. Before any ore is sent such circular should be obtained and carefully read, together with the undermentioned rates, and in dealing with consignments it will be taken for granted that the consignor has had full particulars of the company's conditions, and the undermentioned charges, and agrees to abide by them.

Charges for Treating Ores, &c.

	Per 20 cwt. net dry weight.
Gold ores (crude)	From 40s. to 45s.
,, concentrates, blanketings, tailings, and slimes	40s.
Silver ores (crude)	From 40s. to 45s.
Lead ores (carbonate)	,, 33s. to 39s.
,, (sulphide)	,, 35s. to 43s.
Copper ores (carbonate)	35s.
,, (sulphide)	40s.
,, (carbonate) containing gold	35s. and a gold extraction charge of 3d. per unit of the copper.
,, (sulphide) ,, ,,	40s. and ditto.
,, (carbonate) ,, silver	35s. and a silver extraction charge of 1s. per unit of the copper.
,, (sulphide) ,, ,,	40s. and ditto.
Antimonial and arsenical ores	From 45s. to 50s. and 1s. per unit for antimony and (or) arsenic over 5 per cent.

Class No.		
39.	Copper ores (carbonate)	35s.
40.	,, (sulphide)	40s.
41.	,, containing gold and (or) silver.	

Copper smelting rate (as on copper ores), viz. :—Carbonates, 35s. ; sulphides, 40s. ; and gold extraction charge reckoned on the basis of 3d. for each unit of copper (fire assay) in the ore ; and silver extraction charge reckoned on the basis of 1s for each unit of copper (fire assay) in the ore.

Where the gold (and) or silver left after usual deductions are made will not pay for extraction, that metal, or those metals, are disregarded and the ore treated as a copper ore only.

Prices paid for Metals in Ores.

Gold—£4 per oz. fine, except where copper is paid for; when copper paid for, gold paid for at £3 15s. per oz. fine.

Silver—The company's latest weekly telegraphed London quotation for standard silver at date of agreement of assays.

Lead—The company's latest weekly telegraphed London quotation for Spanish lead at date of agreement of assays, less £2 10s. per ton for London realisation charges.

Copper—Will be paid for at 6d. per unit less than the company's latest weekly telegraphed London quotation for Chili bars.

The Australian Smelting Company, Limited.

Will purchase ores on the following tariffs, subject to the following conditions :—

Ore to be delivered to the works at Dry Creek Station, South Australia, or to the company's agent, as may be arranged, at owner's risk and expense, and freight prepaid, unless otherwise arranged for.

Ore sent to the Smelting Company's works should be properly marked, a different number or letter being used for each class, and the company should be immediately notified of its despatch.

The Smelting Company guarantees correct weights, samples and assays.

The weights to be agreed between the seller's representative and an fficial of the Smelting Company.

The ore to be sampled and moisture determined in the usual manner, in the presence of the seller's representative, and in all cases the actual moisture to be deducted.

The sample to be divided into four parts ; one to be retained by the Smelting Company, one to be taken by the seller's representative, one to be sealed by the seller's representative and an official of the Smelting Company as an umpire sample, and the remaining one to be sent to the seller.

Assays to be made by the fire method, and the reports, both of the Smelting Company and the seller's representative, to be sent to the seller, who is to agree the same with the Smelting Company or, in case of disagreement, to refer the sample to an umpire assayer, and the mean of the two nearest assays is to be accepted as final.

The umpire assayer is to be mutually chosen, and to be paid by the party whose assay shows the greatest difference.

No fraction of a pennyweight of gold, of an ounce of silver, or of an unit of lead to be taken into account.

Draftage of 1 lb. per hundredweight to be allowed in all cases to the buyer.

A charge is made for crushing, sampling, and assaying ore bought by the Smelting Company. In the event of the owner being dissatisfied with the buyer's valuation, he is at liberty to remove the ore upon payment of the cost of crushing, sampling, assaying and reloading.

The owner to declare, within ten days after receipt of notice of valuation, whether it be accepted or not. After that time storage will be at owner's risk and expense.

Special arrangements are made for extended contracts.

Payment for ore will be made thirty days after agreement of assays, and adjustment of silver values on realisation.

All samples of ore should be addressed to the works, Dry Creek Station, South Australia.

Gold Ores.—Payment to be made at the rate of £4 per oz. of fine gold, subject to the following deductions and conditions :—

When the ore gives by assay 4 oz. and over per ton of 2,240 lb., deduct 1½ dwt. per oz.
,, ,, ,, ,, under 4 oz. ,, ,, ,, 2 ,, ,,

Ordinary smelting charge, 50s. per ton of 2,240 lb. for sulphide ores.
,, ,, ,, 30s. ,, ,, for oxidised ores.

When the ore contains more in the aggregate than 7 per cent. of zinc, antimony, arsenic, copper, a penalty of 1s. 6d. per unit to be enforced.

All lead over 10 units will be paid for at 40s. per ton under London quotation for soft Spanish lead.

When copper exceeds 3 units, payment will be made for it under a special tariff.

Gold and silver ores.—The gold to be paid for subject to the same deductions and conditions as in the above gold ore tariff.

The fine silver is to be paid for at the London quotations for standard silver, less the following deductions :—When the ore assays 14 oz. and under deduct 3 oz. per ton. When the ore assays 15 to 20 oz. and under deduct 4 oz. per ton

Above 20 oz. as per tariff for ordinary silver ores, and then the risk of the silver market to be borne by the sellers.

For copper ores containing both gold and silver a special tariff will be given.

Silver and lead ores.—Silver to be paid for at 3d. per oz. under standard price, thirty days after agreement of assays, or as may be arranged, adjustment to be made on realisation, but not later than ninety days after, at the then price of standard silver in London, less the following deductions per ton :—

When the ore gives by fire assay :—

15 oz. and under, deduct	3 oz, per ton.	50 oz. and under, deduct	7 oz. per ton.
20 ,, ,, ,,	4 ,, ,,	65 ,, ,, ,,	8 ,, ,,
30 ,, ,, ,,	5 ,, ,,	80 ,, ,, ,,	9 ,, ,,
40 ,, ,, ,,	6 ,, ,,	100 ,, ,, ,,	10 ,, ,,

Above 100 oz. deduct 10 per cent.

A deduction of 5½ per cent. is also made on the silver paid for, to cover desilverising charges in London.

For lead payment to be made for each unit above 12 in the case of carbonates, and 15 in the case of sulphides, at the rate of London quotations for the week previous for soft Spanish lead, less 40s. per ton, such price to be fixed by weekly telegram.

Smelting charges, 27s. 6d. to 60s. per ton according to character of ore.

Smelting charges scale—

For carbonate ores	27s. 6d.	to 35	shillings per ton.
,, dry oxidised ores...........	35s.	,, 50	,, ,,
,, sulphide ores	35s.	,, 60	,, ,,

Ores containing less than 12 per cent. lead are considered as dry ores.

When the ore contains zinc an extra allowance of one shilling for each unit of zinc in excess, to be chargeable under the following rate :—

When the ore contains	20 per cent. lead or less,	charge	1s.	per unit for all zinc over	5 units.
,, ,, ,,	21 ,, ,, to 25 per cent.	,,	1s.	,, ,, ,,	6 ,,
,, ,, ,,	26 ,, ,, to 30 ,,	,,	1s.	,, ,, ,,	7 ,,
,, ,, ,,	31 ,, ,, to 35 ,,	,,	1s.	,, ,, ,,	8 ,,
,, ,, ,,	36 ,, ,, to 40 ,,	,,	1s.	,, ,, ,,	9 ,,
,, ,, ,,	41 ,, ,, to 50 ,,	,,	1s.	,, ,, ,,	10 ,,

For all other conditions see commencement of tariff sheet.

For the Australian Smelting Company, Limited. C. W. Chapman, Managing Director.

Smelting Works, Dry Creek Station, South Australia, March 1st, 1896.

J. M. Higgins, Metallurgist.

Head Office, 39, Queen-street, Melbourne, T. Rollason, Secretary.

The Great Cobar Copper-mining Syndicate.

Copper-smelting and Refining Works, Lithgow. P. H. Goldsmid, Superintendent.

Tariff for Purchase of Ores.

The ores dealt with in this tariff are classified as follows :—

Class A.—Ordinary copper ores.

Class B.—Copper ores containing gold and (or) silver. In this Class are included all ores which contain sufficient copper to pay the copper-smelting charges under Class A, and sufficient gold and (or) silver to pay the additional treatment charge under Class B after the usual deductions have been made for loss of gold and silver.

Class C.—Gold ores. In this Class are included all pyritous or other gold ores (whether roughs or concentrates), containing gold, or gold and silver, but without any copper to value.

Class D.—Silver ores. In this Class are included only silver ores containing less than 10 per cent. of lead or zinc.

General Conditions of Purchase.

All ores are purchased delivered at the Smelting Works, Lithgow, and are to be weighed on the syndicate's scales.

Copper ore will be paid for at a unit price equal to the latest telegraphed cash price for Chili bars or G.M.B. copper, less 6d. per unit.

Gold will be paid for at £4 per oz. for fine gold.

Silver will be paid for at the latest telegraphed London quotation for standard silver at date of agreement of assays.

Terms of payment.—Prompt cash on agreement of assays.

Scale of deductions for loss of gold and silver.—On silver in all Classes of ore, the first 5 oz. will in no case be paid for.

For ore assaying	30 oz. and under,	5 oz.	will be deducted.
,, ,,	40 ,, ,,	6	,,	,,
,, ,,	50 ,, ,,	7	,,	,,
,, ,,	65 ,, ,,	8	,,	,,
,, ,,	80 ,, ,,	9	,,	,,
,, ,,	100 ,, ,,	10	,,	,,
,, ,,	120 ,, ,,	11	,,	,,
,, ,,	140 ,, ,,	12	,,	,,
,, ,,	160 ,, ,,	13	,,	,,
,, ,,	180 ,, ,,	14	,,	,,
,, ,,	200 ,, ,,	15	,,	,,
,, ,,	225 ,, ,,	16	,,	,,
,, ,,	250 ,, ,,	17	,,	,,
,, ,,	275 ,, ,,	18	,,	,,
,, ,,	300 ,, ,,	19	,,	,,
,, ,,	400 ,, ,,	20	,,	,,
,, ,,	above 400 oz.,	5 per cent. on silver contents.		

On gold contents of ores in Class B—Copper ores containing gold, 10 per cent. of gold contents; Class C—Pyritous and other gold ores and concentrates, 10 per cent. of gold contents.

Class A—Ordinary copper ores (21 cwt. to the ton), are paid for at a unit price for copper as above, less the following scale of smelting charges :—

Percentage of Ore.			Sulphide Class.	Oxide Class.
	Up to 8	per cent.	£2 0 0 per ton net	
Over 8 per cent., and up to	10	,, ...	2 2 6 ,, ...	£2 0 0 per ton net
,, 10 ,, ,,	15	,, ...	2 5 0 ,, ...	2 2 0 ,,
,, 15 ,, ,,	20	,, ...	2 15 0 ,, ...	2 4 0 ,,
,, 20 ,, ,,	25	,, ...	3 0 0 ,, ...	2 6 0 ,,
,, 25 ,, ,,	30	,, ...	3 5 0 ,, ...	2 8 0 ,,
,, 30 ,, ,,	35	,,	Special rate	... 2 10 0 ,,
,, 35 ,, ,,	40	,,	Special rate	Special rate
,, 40 ,, ,,	45	,,	Special rate	Special rate
,, 45 ,, ,,	50	,,	Special rate	Special rate

These rates are for copper ores free from impurities. In the case of ores containing arsenic, antimony, tin, zinc, bismuth, &c., the smelting charges will be higher than stated above, and will vary with the nature and quantity of the impurity present.

Class B.—Copper ores containing gold and (or) silver are paid for :—First, as copper ores, at 21 cwt. to the ton, less smelting charges as per scale under Class A. Second, as silver, or gold and silver ores, at 20 cwt. to the ton, less an additional treatment charge of £2 per ton, and deductions as above for loss of gold and silver.

Class C.—Gold Ores (20 cwt. to the ton.)—Are paid for at the value of the gold or gold and silver contents, as determined by fire assay, less a smelting charge of £2 10s. per ton, and deductions as above for loss of gold and silver.

The above rates are for ores free from antimony ; for ores containing this element, special rates will be quoted on application.

Class D.—Silver ores, (20 cwt. to the ton), are paid for at the value of the silver contents, as determined by fire assay, less a smelting charge of £2 15s. per ton, and deductions as above for loss of silver.

These ores must not contain more than 10 per cent. of lead, except under special arrangement, and no lead will be paid for ; nor must they contain more than 10 per cent. of zinc, except under special arrangement, and for all zinc over 5 per cent. a special deduction of 2s. per unit will be made.

Method of sampling and agreement of assays.

Three samples will in all cases be taken, one to be retained by the seller, one by the syndicate, and the third sealed and kept as a reference sample.

The seller or his agent may be present at the weighing and sampling.

A charge of £1 1s. will be made for weighing and sampling on all parcels of 10 tons and under, and 2s. for each ton over 10 tons.

The copper contents of ores to be determined in all cases by Cornish copper assay, and the gold and silver contents by fire assay.

If the seller's assay differs from that of the syndicate, the difference will be divided if it does not amount to more than 1 per cent. in the case of copper, 2 oz. in the case of silver, and 2-10ths of an oz. in the case of gold; but, if the difference is greater than this, the reference sample will be submitted to an independant assayer, to be selected by agreement between the seller and the syndicate, and a settlement will be made on the middle assay of the three. The cost of the reference assay to be paid by the party whose assay differs most from that of the referee.

In settling assays no fraction of an oz. of silver nor less than 1-10th of an oz. of gold will be taken into consideration, except as the result of the buyer's and seller's assays being divided as above.

From the weight of all ores the actual moisture contained therein will be deducted.

Sellers can arrange for freight and railway carriage to be paid by the syndicate at Lithgow, and deducted from account sales of ore. On ore from the other colonies all charges must be paid to port of shipment.

Parcels of ore should in every case be consigned to the Superintendent of the Smelting Works, Lithgow.

Any further information can be obtained by application to P. H. Goldsmid, Superintendent of the Smelting Works, Lithgow.

Wallaroo Smelting Works, Wallaroo, South Australia.

Proprietors—Wallaroo and Moonta Mining and Smelting Company, (Limited); Secretary—D. Davidson, Universal Buildings, Grenfell-street, Adelaide; Works Manager—T. C. Cloud Assoc. R.S.M., F.I.C., F.C.S.

Tariff for purchase of ores.

The ores dealt with in this tariff are as follows, viz. :—

Copper ores.—Whether containing payable quantities of gold (and) or silver or not.

Gold ores.—Including all pyritous or other gold ores (whether roughs or concentrates) containing gold, or gold and silver.

Silver ores.—Containing 12 per cent. of lead or under.

Lead ores.—Containing over 12 per cent. of lead, whether containing payable quantities of silver or not.

General conditions of purchase.

All ores are purchased delivered at the Wallaroo Smelting Works, Wallaroo, and are to be weighed on the company's beam scales, at 20 cwt. 2,240 lb. to the ton.

Three samples will in all cases be taken, one to be retained by the seller, one by the company, and the third to be sealed and kept as a reference sample.

The seller or his agent may be present at the weighing and sampling.

No charge shall be made for weighing and sampling except in the case of piles weighing less than two (2) tons; on these the charge will be £1 1s. for each pile.

The copper contents to be determined in all cases by improved cyanide or electrolytic method, and the lead, gold, and silver contents by fire assay.

Assay results to be reported as follows, viz. :—Silver to 0·5 oz.; gold to 0·05 oz.; Copper to 0·1 per cent.; lead to 0·5 per cent.

Copper Contents.—From the copper as determined by wet assay, the following deductions will be made :—

On ores assaying	up to 10 per cent.	2 units.
,, ,,	over 10 per cent. and up to 20 per cent.	2½ ,,
,, ,,	over 20 per cent.	3 ,,

N.B.—The old customary allowances on these ores of 1 cwt. in every ton, and draftage of 1 per cent. are now abolished.

Copper will be paid for at the latest telegraphed cash price for G.M.B. Copper.

Gold contents.—On ores containing gold not exceeding 1 oz., 1-10th of an oz. will be deducted, and the remainder paid for at £4 per oz. On ores containing more than 1 oz., 95 per cent. of the total gold contents will be paid for.

Silver contents.—On ores containing silver in excess of 5 oz., all the silver will be paid for at the latest telegraphed price for standard silver. If the silver does not exceed 5 oz., no silver will be paid for.

Smelting charge.—The smelting charge on these ores will be quoted on receipt of representative sample of the ore.

For carbonate and oxide ores, free from impurities, specially low smelting charges will be quoted.

Special quotations and terms will be quoted on application for the following, viz. :— Argentiferous, leady, and pure copper mattes.

For these a representative sample should accompany the letter of inquiry.

Argentiferous and auriferous copper.

Lewis Lloyd's Copper Smelting Works, Lithgow.

Sydney office: 19 and 20, Norwich Chambers, Hunter-street.

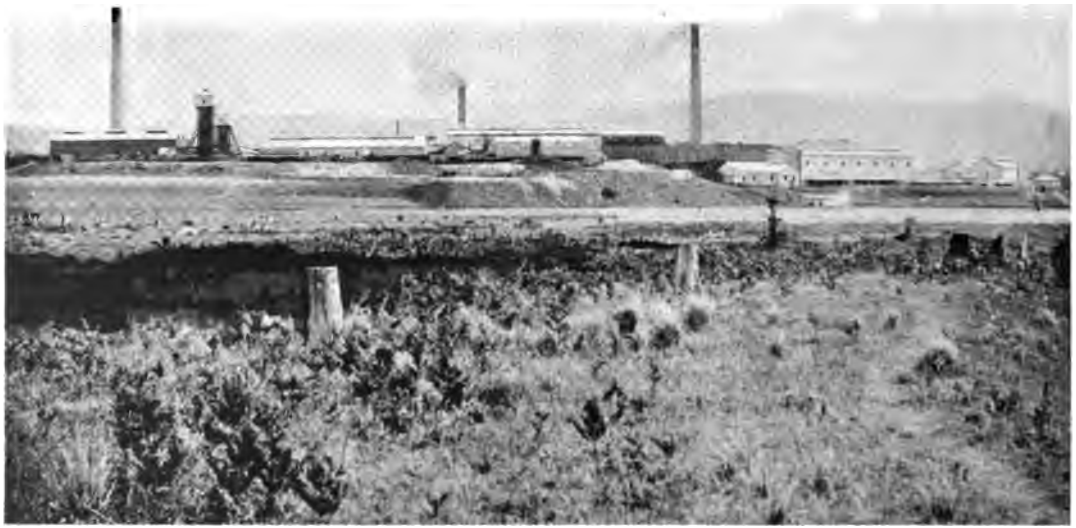
Smelting charge from £2 to £2 10s. per ton of 21 cwt., according to quality. Sampling free. Payment on agreed assays of samples taken under the usual conditions in copper smelting.

Sydney: William Applegate Gullick, Government Printer.—1899.

ENGLISH AND AUSTRALIAN COPPER SMELTING WORKS, WARATAH, NEAR NEWCASTLE.

English and Australian Smelting Works (Interior), Waratah, near Newcastle.

The Australian Smelting Company's Works, Dry Creek, near Adelaide.

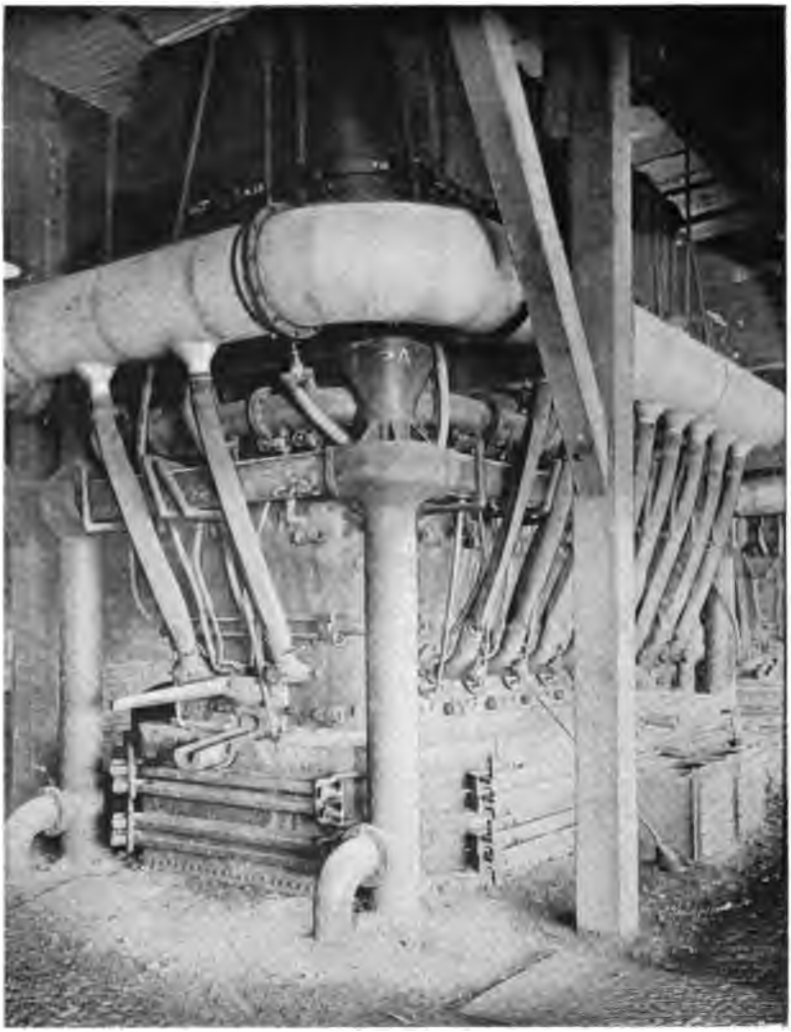


The Smelting Company of Australia's Works, Lake Illawarra, near Dapto.

The Smelting Company of Australia's Sulphuric Acid Works, Lake Illawarra, near Dapto.

THE SMELTING COMPANY OF AUSTRALIA'S WORKS, LAKE ILLAWARRA, NEAR DAPTO.

(Ore Bins, &c.)



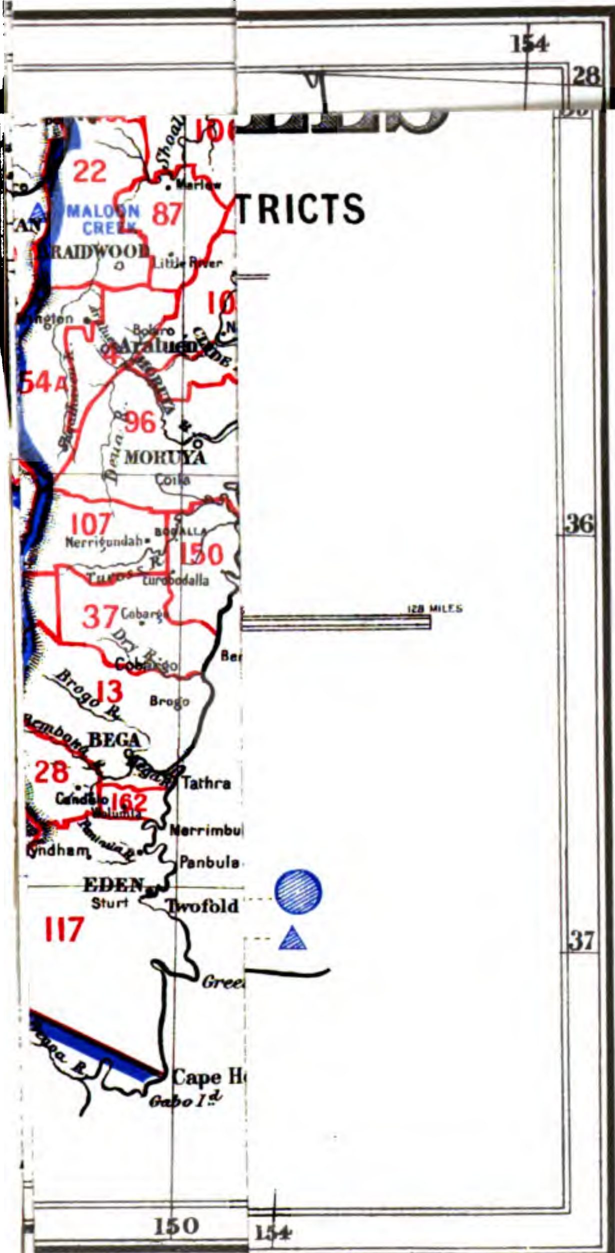
THE SMELTING COMPANY OF AUSTRALIA'S WORKS, LAKE ILLAWARRA, NEAR CAPTO.

(Blast Furnace.)

GREAT COBAR COPPER MINING SYNDICATE'S REFINERY, LITHGOW.

GREAT COBAR COPPER MINING SYNDICATE'S REFINERY, LITHGOW.

(Interior View. Filling ingot moulds in foreground.)


154
28
TRICTS
22
MALOON CREEK
87
BRAIDWOOD
Little River
Araluen
54A
96
MORUYA
Deua
107
Nerrigundah
BODALLA
150
Eurobodalla
37
Cobargo
13
Brogo
BEGA
28
Tathra
Candelo
162
Merrimbul
Pambula
EDEN
Sturt
Twofold
117
Cape H
Gabo Id
128 MILES
36
37
150
154

Date Due